ELECTRICAL ENGINEERING

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Contents

A Salute to the American Institute of Electrical Engineers *Gunnar Gundersen* 623

New EHV Cable Research Laboratory Features Unique Cyclic-Load Test Equipment *L. F. Hickernell*

Increased peak load and future growth make higher voltage transmission necessary, thus the need for an EHV cable research laboratory 624

International Standardization of Static Power Converters *L. W. Morton*

Role of Technical Committee no. 22 of the IEC in evolving international standards for static power converting equipment 633

An Investigation on Elastic Sheath Pressure Cables *N. Klein*

A study has been made on elastic sheath cables, designed to dispense with bulky and expensive means of maintaining pressure in high-pressure cables 638

Engineering Aspects of TASI *Kenneth Bullington, J. M. Fraser*

A system which takes advantage of normal pauses in conversation by interpolating additional speech channels into existing channels is described 639

Analysis and Evaluation of Noise in Household Refrigerators—Part I *E. A. Baillif, J. P. Laughlin*

Discussion of the basic problems which are encountered in the detection, measurement, and evaluation of refrigerator noise 646

The Bode Diagram—An Approach to Regulating-System Stability Fundamentals *L. A. Koenig*

The Bode, or frequency-response, diagram not only provides a means of understanding fundamentals of regulating systems, but also is a useful design tool 653

Rationalization of Electrical Clearances at EHV's 230 Kv to 460/500 Kv *P. L. Bellaschi*

A basic approach that switching surges together with the 60-cycle operating voltage primarily determine clearance requirements at the higher voltages 659

Submarine D-C Cable Interconnection between Great Britain and France *F. M. Cahen, R. A. Tellier*

Concluding article on two transmission projects which may have far-reaching results in the electrical and allied fields 664

The Institute and Its Operations *L. F. Hickernell*

President Hickernell presents the organizational breakdown of the AIEE and details Institute procedures 672

CONTENTS CONTINUED

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75 Years
A Prologue to the Future

THE COVER: New Extra-High-Voltage Cable Research Laboratory of the Anaconda Wire & Cable Company, Hastings on Hudson, N. Y., has 345,000-volt cable with terminals for 60-cycle high-voltage and impulse testing. A 3-million-volt impulse generator is seen in center background. Story appears on page 624.

Are You Getting The Maximum Life out of Your Paper Cables?

The life of paper-insulated cable is seriously compromised if moisture enters the wall of insulation. That is why a lead sheath is employed. By providing a perfect seal, it prevents moisture from finding its way into the cable. Of course, in order for the sheath to do its job, it must, itself, remain intact.

G. N. Everest
Factory Sales Manager

A study of cable service records has shown that a large percentage of paper cable failures are caused by failure of the sheath. Among others, there are two basic causes of sheath failure. One is electrolytic corrosion; the other is mechanical damage during installation.

Realizing this, Okonite research engineers developed a covering for lead that would not only prevent damage during installation, but, also, would prevent corrosion. This covering was introduced in 1933. We called it Okosheath Protective Covering . . . "OPC" for short. Proof that OPC prolongs the life of lead sheaths lies in the fact that over a quarter of a century ago, since its introduction, not one corrosion failure has been reported.

OPC consists of (1) an Okoprene-impregnated tape which is thoroughly bonded to the lead . . . no chance for corrosive elements to travel next to the sheath, (2) an insulating, corrosion-resistant wall of Okoprene, (3) two outer layers of Okoprene-impregnated tape for additional mechanical protection, and (4) a wax-mica finish to facilitate easier pulling into ducts.

Okoprene is an exclusive Okonite compound. A neoprene base material, it conforms to ASTM requirements . . . is flame, oil, and chemical-resistant. It is mechanically strong, ages well, and possesses the stable insulating qualities required to prevent electrolysis. As a component of OPC, Okoprene is applied to the cable by Okonite's unique strip-insulating process. This assures a wall of absolutely uniform thickness —no thin spots, no areas that are less strong than others.

Cross Section of
Okosheath Protective Covering

Some Environments Pose Special Problems

To suit special environments, Okonite paper cable is often supplied with a thermoplastic covering — Okoseal (polyvinyl chloride base) or Okolene (polyethylene base). These compounds provide excellent sheath protection where extraordinary chemicals will be encountered . . . for example, petrochemical plants.

Submarine cables, also, require special protection for the lead sheath. In addition, long unspliced lengths are usually desirable. Okonite, with its extensive experience and special manufacturing facilities, is well equipped to handle the difficult problems of submarine cable manufacture.

. . . submarine cable, a specialty

1. **The development of Okosheath Protective Covering and**
2. **a record of enviable success in solving other, challenging cable covering problems . . .**

. . . two illustrations of Okonite's leadership . . . leadership that comes from skill in research, skill in manufacturing, and skill in application engineering. Achievements like these point to the fact that Okonite paper cables contain *added values*, values that are not written into specifications. Today, every good engineer I know is seeking ways to get the maximum value out of the money he invests for his company or client. The *added values* in Okonite paper cables provide an opportunity to get extra life and dependability out of electrical cable systems. As one engineer to another, I urge you to become better acquainted with the long range economy of Okonite paper cables.

If you have not received your copy of the new Okonite paper cable catalog, or if I can be of help to you with a current problem, please get in touch with me at The Okonite Company, Passaic, New Jersey.

406

where there's electrical power . . . there's **OKONITE CABLE**

Contents Continued

Technical Paper Digests

A Speed-Setting Transducer	*N. G. Alvis*	631
Integrated Mobile Microwave Communications System	*R. F. Lowe*	632
Synthesis of Control Systems	*C. R. Hausenbauer, G. V. Lago*	636
Thermosiphon Flow in a Model Transformer Oil Circuit	*J. J. Kunes*	637
Spinning Disk Random Selector	*G. A. Roberts*	644
Polyphase Induction Motors with Unbalanced Rotor Connections	*B. N. Garudachar, N. L. Schmitz*	645
The Turbonator: Design and Development	*J. T. Duane, J. W. Harrison*	651
Equations for Induction Motor Torque and Power	*W. H. Middendorf*	652
Effect of Source Impedance on Motor Performance	*Albert Diamond*	677

Departments

Institute Activities	678
Seattle Welcomes AIEE Summer and Pacific General Meeting	678
Atlanta Is Host to Joint District Meeting of AIEE	681
U. S. Computer Technology Leads in Program for Global Computer Conference	683
Change of Address Coupon	683
AIEE Past President Honored by Japanese Engineering Society	684
AIEE Future Meetings	685
Cincinnati First in Nation To Top Engineering Center Goals	687
Nuclear Congress Devoted to Peacetime Uses of the Atom	688
Two Engineers To Receive Lamme Medal	691
Results of the District Prize Papers Competition 1957-58	692
Of Interest to Student Members	699
AIEE Fellows Elected	706
AIEE Personalities	709
Obituaries	710
Of Current Interest	712
Supersonic Air-to-Air Defense Feature of Sparrow III Guided Missile	712
ON KUL, ON SPN, GO RGT, TL LFT, CIRCLE/CTR AT +2, +3, RADIUS, +5	713
Venus Two-Way Contact Makes Radar Echo-Return History	715
Future Meetings of Other Societies	715
Direct A-Power Electricity without Using Steam Turbine	717
Atoms for Living Stressed in Industry-Owned Research Reactor	718
Intense Light for Aerial Flash Unit Developed	719
Flight Safety Helped by Easy-to-Read Altimeter	720
Ultramicroscopic Semiconductor Solid Circuit	721
Letters to the Editor	722
New Books	724
Technical Literature	726
New Products	18A
Industrial Notes	30A
Trade Literature	57A

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"No man can improve an original invention..."

—William Blake

THERE are many scientists today who would argue this point with Blake.

At Bell Telephone Laboratories, for example, we have seen original inventions improved and re-improved countless times, the better to serve mankind.

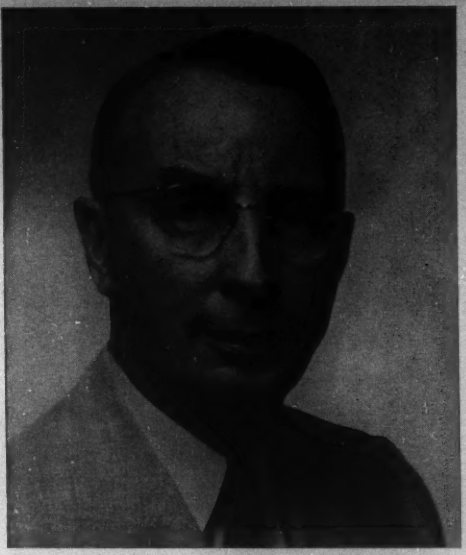
But William Blake went on to say "... nor can an original invention exist without execution organized, delineated and articulated." Here Blake expressed ideas that apply with striking emphasis today. At Bell Laboratories organized effort is constantly aimed at fostering an environment in which inventions can exist and prosper, where they can be expressed either as ideas or in physical form, and where clear understanding of their principles can be achieved.

By helping scientists and engineers to reach for the things they seek, by organizing and coordinating their efforts, Bell Laboratories has made important contributions to the art of communications: proof of the wave nature of the electron, first research in radio astronomy, discovery of the transistor principle, invention of the feedback amplifier. Such ventures into the unknown have twice brought the Nobel Prize to Bell Laboratories scientists, and at the same time have helped create the most efficient and versatile telephone system ever known.

William Blake (1757-1827), a versatile genius, was famous for brilliant, sometimes prophetic, insights which he expressed with provocative beauty in drawing, painting, poetry and prose.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT



Courtesy Fabian Bachrach

A Salute to the American Institute of Electrical Engineers

Modern medicine could not exist without electronics!

From common office instruments to highly complex apparatus used in heart and brain surgery, the advances of electrical engineering are utilized daily in medical practice and research.

Therefore, the American Medical Association has good reason to be grateful to the electrical engineering profession. The progress of science and medicine over the last century has been hand-in-hand, each benefiting from the other's discoveries and developments, and ultimately helping mankind.

Because of the importance of electronics in medicine, the A.M.A. established in 1925 a council to consider and evaluate apparatus for the use of physicians and specialists. Today, the A.M.A. Council on Medical Physics carries on in this field.

Although a large number of electronic developments are used in the specialized medical fields, perhaps the X-ray machine and the electrocardiograph are the most widely used.

Modern X-ray units now provide better and more discriminatory diagnostic help than their predecessors, while measurably decreasing the amount of radiation the patient receives.

Electrical engineering has developed the electrocardiograph into its present compact, accurate, and easily operable form—a considerable improvement over the cumbersome devices of 20 years ago.

In the more specialized fields, electrical engineering has helped develop the electromyograph—important in the differential diagnosis of diseases of the neuromuscular system; the electroencephalograph or the "brain wave" machine—an example of precision engineering in the development of a sensitive detector used in neurologic diagnosis; and cardiac defibrillators, pacemakers, and monitors, used so effectively in heart cases.

Each of these and many others have helped the medical profession in its never-ending task of raising the general health level to the highest possible degree.

On behalf of the American Medical Association, I extend warmest congratulations to the American Institute of Electrical Engineers on its 75th Anniversary. The medical profession looks with gratitude and respect on the past progress of electrical engineering, and it feels that the next 75 years will be even more fruitful than the last.

Gunnar Gundersen, M. D.
President, 1958–59
American Medical Association

75 Years—
A Prologue to the Future

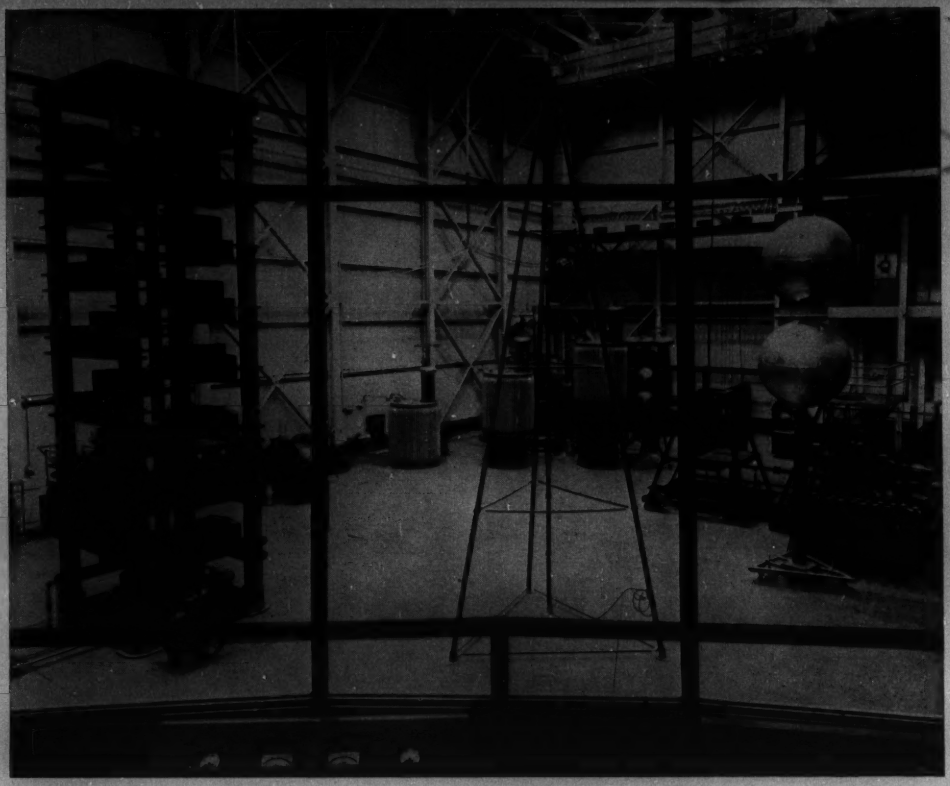


Fig. 1. View of EHV Cable Research Laboratory from observation and control gallery.

New EHV Cable Research Laboratory

Features Unique Cyclic-Load Test Equipment

L. F. HICKERNELL
PRESIDENT AIEE

FROM 1945 TO 1958, the noncoincident peak load in the United States increased from 40- to 118-million kw, tripling in 13 years. Future load growth at anywhere near this rate will require higher voltage transmission. Difficulty of obtaining right-of-way for additional and higher voltage overhead lines will increase demand for extra-high-voltage (EHV) insulated cable; capable of transmitting 500 mva and over at 230 kv and higher.

Fig. 2 shows that cable voltage ratings have increased steadily. Short lengths of 380- and 425-kv cables in Sweden operate under ideal thermal conditions not prevalent in the United States; i.e., in ventilated shafts at low ambient temperatures.

Fig. 3, however, indicates that conventional designs for underground service practically have reached their maximum power capability. For example, 1,500-MCM (thousand-circular-mil), 380-kv impregnated-paper pipe-type cable with initial dielectric power factor of 0.22% would have a capability of 340 mva. Should the power factor increase to 0.3% during service, the rating would be reduced to 270 mva (or 20%).

L. F. Hickernell is vice-president–engineering, Anaconda Wire & Cable Co., Hastings on Hudson, N. Y.

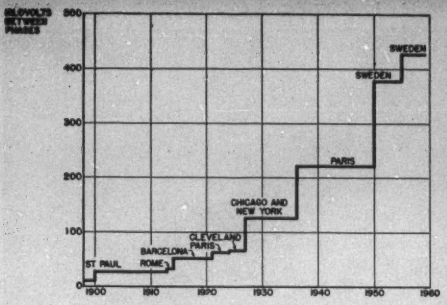


Fig. 2. Increase in cable voltage ratings.

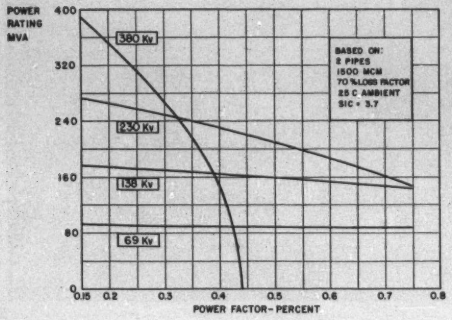


Fig. 3. Effect of dielectric power factor on cable power capability.

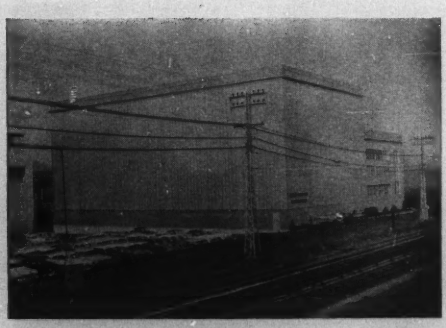


Fig. 4. Exterior of EHV Cable Research Laboratory located at Hastings on Hudson, N.Y., between Hudson River and New York Central Railroad.

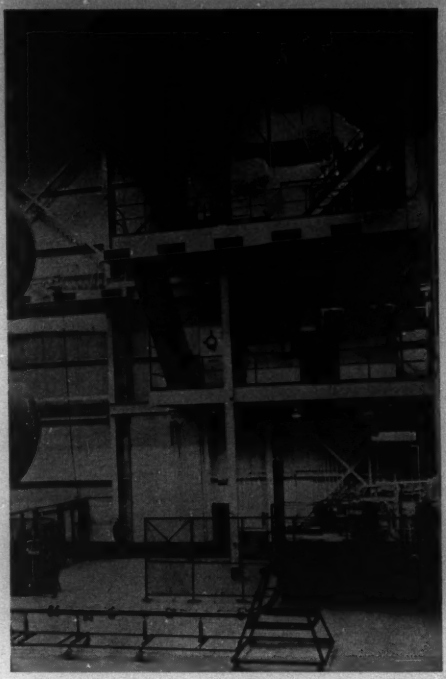


Fig. 5. (*top and middle levels*) 40,000-cfm blower and silica-gel adsorber installation, (*floor*) 200-lph oil-degassing plant.

Clearly, to transmit underground 500 mva and over, lower dielectric losses (i.e., lower power factor and specific inductive capacity) and improved cable-system designs are indicated. Of equal importance is the development of adequate joints and terminals.

Recognizing this need, and as a contribution to the industry's progress, the Anaconda Wire & Cable Co. has constructed and placed in operation during the last 2 years an ingeniously designed EHV Cable Research Laboratory. Costing $1,750,000, it contains a unique assembly of the finest of equipment for evaluation of EHV cable and accessory designs. In addition to 60-cps a-c and impulse voltage testing, facilities are provided to cyclic-load test simultaneously, at 150% rated voltage at operating or higher temperatures, six 150-foot lengths of full-sized (2,500 MCM) commercial 345-kv cable complete with joints and terminals.

BUILDING

Fig. 4 shows the exterior of the building, interior dimensions of which are 151½ feet long by 87 feet wide by 68 feet high, floor to ceiling. The 60-foot clearance from floor to underside of trusses, hence building height, is determined by 34-foot high impulse generator plus 26-foot electrical striking distance (Fig. 8). Width is similarly determined by size and location of equipment,

Fig. 6. View of EHV Cable Research Laboratory toward observation and control gallery.

and electrical clearance (Fig. 9). Floor area is 13,180 square feet.

The 14- by 16-inch wide-flange 150-pounds-per-foot H-beam columns on 21-foot 5-inch centers are supported by seventy-four 30-ton-bearing concrete-filled steel-shell piles, the longest being 48 feet. Factory fabricated side wall panels consist of 16-gage fluted aluminum exterior, 1½-inch glass-wool insulation, 18-gage galvanized steel interior, with caulked joints. Interior steel siding is spot-welded each foot to steel girts spaced on 8-foot centers.

Base is brick exterior and concrete-block interior finished with stucco over wire mesh spot-welded each 2 feet to building steel. Roof is constructed of 20-gage sheet-steel decking spot-welded to each purlin spaced on 7-foot centers, covered with Koroseal vapor barrier, 2-inch fiberboard insulation, and 5-ply asbestos-felt roofing.

Shielding and Grounding

The 9-inch concrete floor, designed for 500-psf (pound per square foot) dead load, is poured over continuous copper-sheet vapor barrier laid on crushed-rock base. Bottom 6-inch pour encases steel reinforcing rods, welded on alternate 2-foot centers. Over this floor is

Fig. 7. Control consoles and oscilloscope in observation and control gallery.

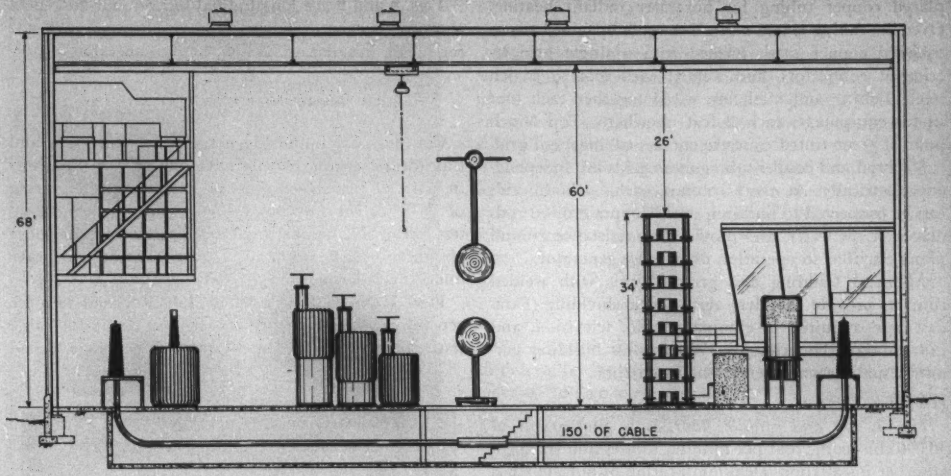


Fig. 8. Longitudinal section of EHV Cable Research Laboratory.

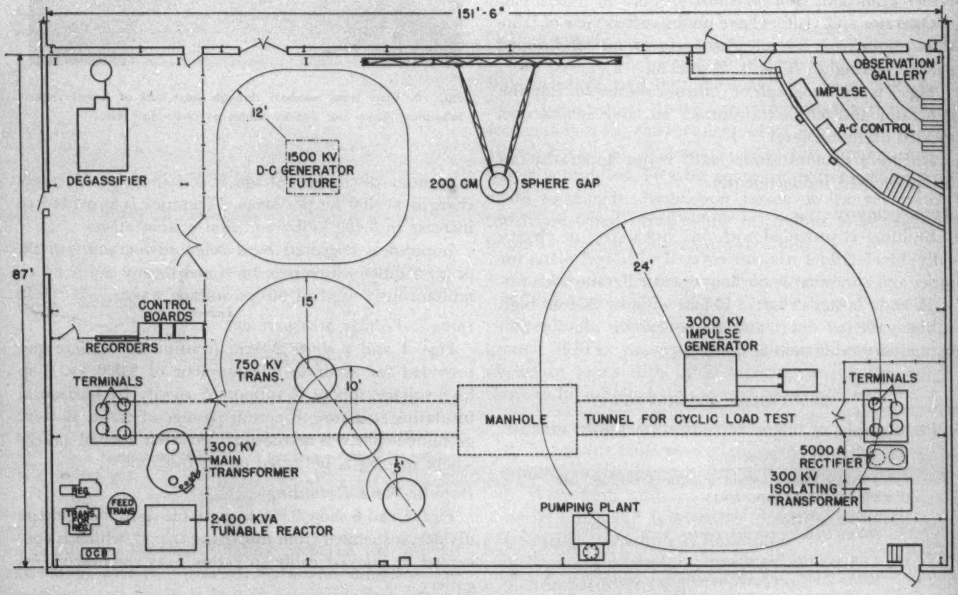


Fig. 9. Floor plan of EHV Cable Research Laboratory.

placed copper tubing for hot-water radiant heating. Over the tubing is laid a No. 8 Awg, 6- by 6-inch silver-soldered copper mesh formed into a single grid by crimped connectors, and welded each foot to trench steel. Tubing and mesh are wired together each foot under equipment; each 2 feet elsewhere. Top 3-inch pour of green-tinted concrete encases tubing-mesh grid.

Steel-rod and copper-tubing-mesh grids are independent electrically. At every column, each or both grids can be connected to building steel. Copper ground rods driven below water level provide zero-resistance ground plane essential to operation of impulse generator.

All-metal building and ground grids with welded contacts provide complete electrostatic shielding (Faraday cage) required to eliminate radio, television, and railroad-signal interference. Windowless building permits visual-corona observations in daytime.

Humidity Control

Fig. 5, *top and middle floor,* is a photograph of 40,000-cfm (cubic foot per minute) blower and silica-gel adsorber installation. Dehumidification of outside air is accomplished by a 150-ton refrigeration unit. Complete system maintains 40% relative humidity in laboratory under anticipated maximum atmospheric conditions. Vapor transmission through floor is prevented by continuous copper-sheet barrier, and through roof by Koroseal barrier. All joints in metal siding are sealed.

Controlled low humidity is essential for adequate preparation of EHV joints and terminations, and for accurate and consistent voltage measurements.

Observation and Control Gallery

Operator and visitors have unobstructed view of laboratory floor from 5-level, glass-enclosed, air-conditioned gallery seating 23 (Figs. 1, 6, and 9).

Fig. 7 is a photograph of control consoles for impulse generator and 60-cps transformer set, and oscilloscope, located on lowest level.

During a demonstration, each major apparatus can be spotlighted independently.

Appurtenances

Building is provided with 587 linear feet of electrically shielded floor trenches covered with steel plates for pipes and conduits; 5-ton floor-operated crane with catwalk and "bosun's chair"; 10-foot wide by 20-foot high rubber-gasketed door; and 50-foot-candle illumination by mercury-vapor ceiling fixtures.

ELECTRICAL APPARATUS

Photographs of major apparatus are shown in:

Figure	*Apparatus*
1	3,000-kv 150-kw-second impulse generator, *left* 200-cm sphere gap, *right* 3,000-kv voltage divider, *center* 750-kv transformer set, *center, back*
11	2,400-kva tunable reactor, *left, back* 300-kv 2,400-kva main transformer, *center, left* 13.2-kv 360-kva voltage regulator, *right, back*
13	5,000-ampere rectifier, *center* 300-kv isolating transformer, *right*

Figs. 8 and **9** are longitudinal section and floor plan showing location of major apparatus. Provision is made for future installation of 1,500-kv d-c generator.

3,000-KV IMPULSE TESTING

Conventional impulse generators for porcelain and transformer testing usually have one or two capacitors in parallel per stage, with an energy capacity rating of 37½ or 75 kw-second. These are inadequate to test EHV cable because high capacitance load precludes obtaining AIEE Standard 1½x40 microsecond wave under loaded conditions.

Figs. 1 and **6** show 3,000-kv 150-kw-second impulse generator, highest energy capacity yet built for cable testing, having four parallel capacitors per stage. Rated

Fig. 10. View from manhole through west half of tunnel under laboratory floor; four 345-kv cables on cyclic-load test.

maximum discharge voltage is obtained by 30 stages charged at 100 kv per stage. Clearance is provided to increase to 3,400 kv by addition of four stages.

Impulse is triggered by a solenoid-operated switch, or by a pulse which may be timed to any point on simultaneously applied 60-cps voltage wave.

Impulse-Voltage Measurement

Figs. 1 and **6** show 200-cm (centimeter) sphere gap provided for accurate measurement of 3,000 kv. Top high-voltage sphere is supported rigidly by horizontal insulating structure to permit passage of crane. Bottom grounded sphere is motor-operated from floor of gallery where spacing is indicated on an instrument.

Impulse-Wave Recording

Figs. 1 and **6** show 3,000-kv variable-resistance voltage divider, suspended from insulating tripod, which is connected by coaxial cable to cathode-ray oscilloscope in gallery.

Floor Test Sample

Fig. 6, *right,* shows 55-foot 345-kv cable with 380-kv

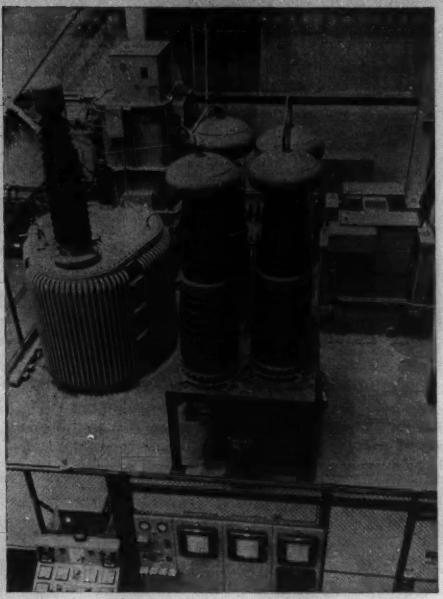


Fig. 11. A-c voltage equipment for cyclic-load test—(*left, back*) 2,400-kva tunable reactor, (*right, back*) 13.2-kv 360-kva voltage regulator, (*left, center*) 300-kv 2,400-kva main transformer, (*center*) 380-kv terminals on cables in tunnel, (*left, front*) control console for reactor, and (*center, front*) panels for power factor and temperature recorders.

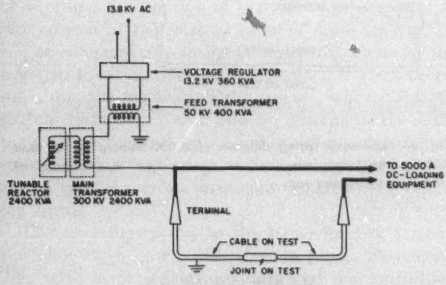


Fig. 12. Schematic wiring diagram of 2,400-kva tunable reactor and 300-kv transformer connected to apply a-c voltage to cables on cyclic-load test.

terminals and sheath insulators prepared for impulse and 60-cps dielectric-strength tests, and dielectric loss measurements. Cable is heated by circulating current through lead sheath from 1,000-ampere arc-welding transformer.

750-KV 60-CPS TESTING

Fig. 1, *center,* shows three 250-kv 150-kva transformers which can be connected in cascade for 750-kv single-phase, or Y-grounded for 433-kv 3-phase. They are energized from 450-kva sine-wave motor–generator set controlled from floor or gallery.

Dielectric loss measurements on floor samples (Fig. 6) are made by portable shunted-arm modified-Schering bridge with grounded guard circuit. When used with 100 μμf standard capacitor, bridge measures capacitances from 76 μμf to 2 μf.

CYCLIC-LOAD TESTING

To evaluate cable designs, the most effective test is to determine the dielectric power factor stability under elevated voltage and temperature. This is accomplished by measuring power factor while circulating current in the conductor on daily cycles to heat the insulation above operating temperature, and simultaneously applying overrated a-c voltage.

For EHV cable designed to transmit from 500 to 750 mw, size of apparatus and power consumed using conventional current-loading and power transformers (suitable for 138-kv and lower cable) are excessive. Some laboratories have resorted to specially constructed small-sized or high-resistance conductors to reduce power input.

By ingenious design, this laboratory is equipped to test full-size (up to 2,500 MCM) commerical EHV cables under actual or more severe operating conditions.

Cable Tunnel

Fig. 10 is a photograph of 40-foot long by 16-foot wide manhole, and half the length of 6-foot wide by 7-foot high tunnel under laboratory floor which will accommodate six 150-foot lengths of cable with joints (Figs. 8 and 9). Automatic CO_2 fire extinguishing system is installed. Flexible connections from cables are made to plug-in connection boxes on tunnel walls which are wired permanently in conduit to automatic power-factor and temperature recorders.

300-kv Tunable Reactor and Transformer

Six 150-foot lengths of 345-kv cable tested at 150% rated voltage require up to 2,400 kva at 300 kv to ground (520 kv phase-to-phase). A tunable reactor connected in series with cable capacitance requires only losses to be supplied. Advantages of reactor are:

1. 90% reduction in kva demand
2. Automatic fault protection avoids burning cable since circuit is instantly self-detuning
3. Wave form is undistorted because resonance between cable and transformer reactance at supply-frequency harmonics is impossible
4. Future increase in voltages is facilitated
5. Apparatus costs less

Fig. 11 is a photograph of 2,400 kva moving-coil reactor, 300-kv main transformer, 13.2-kv voltage regu-

lator, and control console above which is automatic voltage control unit. In center are four 380-kv terminals on cables in tunnel.

Fig. 12 is a schematic wiring diagram of tunable reactor and transformer connected to apply a-c voltage to cable on cyclic-load test.

5,000-Ampere Rectifier and Transformer

Fig. 13 shows shielded germanium rectifier mounted on two 300-kv insulating cylinders through which cooling air is blown; 300-kv isolating transformer; four 380-kv terminals on cables in tunnel. The 50-volt rectifier output voltage is adequate to overload six 150-foot lengths of 2,500 MCM cable in series.

Fig. 14 is a schematic wiring diagram of rectifier and transformer connected to circulate d-c in conductor of cable on cyclic-load test.

Fig. 6, *upper right,* shows 520-kv 5,000-ampere 4-conductor bundled overhead line used as return circuit when testing odd number of cables in tunnel.

Instrumentation

Fig. 11, *center foreground,* shows panels on which are automatic temperature recorders, and power-factor bridge which records a measurement each minute, and can be set to de-energize test at any predetermined value.

MECHANICAL EQUIPMENT

Fig. 5, *bottom floor,* shows location of 200-lph (liters per hour) oil-degassing plant. Full-sized 200-psi oil-pumping plant is provided to maintain pressure on pipe-type cable.

PERSONNEL SAFETY

Doors, permanent and movable fences, and manhole cover are interlocked independently to three controls; impulse generator, 60-cps transformer set, and reactor–rectifier installation. Emergency pushbutton control is located outside laboratory.

Fig. 8 shows four 10,000-cfm motor-driven roof vents provided for fast clearance of air in laboratory in emergency. Fresh-air packs are available for rescue if CO_2 extinguisher operates when personnel is in tunnel. Safety hats are used when adjusting equipment.

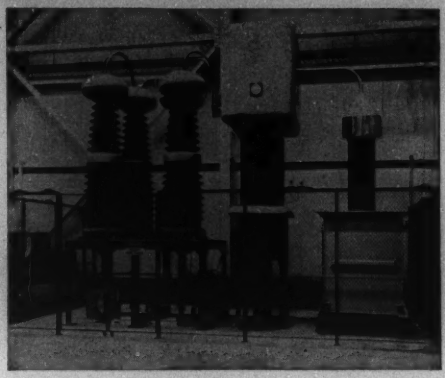


Fig. 13. D-c rectifier equipment for cyclic-load test—(*center*) 5,000-ampere rectifier on 300-kv insulating pedestals, (*right*) 300-kv isolating transformer, and (*left*) 380-kv terminals on cables in tunnel.

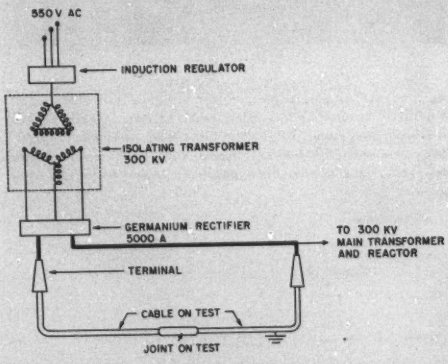


Fig. 14. Schematic wiring diagram of 5,000-ampere rectifier and 300-kv transformer connected to circulate d-c in conductors of cables on cyclic-load test.

OPERATION

As soon as each installation of major apparatus was completed, it was put into operation; the last having been on December 5, 1958, when the cyclic-load test was energized. After usual breaking-in period, equipment is performing as designed.

This additional and distinctive EHV laboratory, together with those devoted to the development of improved insulating materials, provides the cable research facilities necessary to enable underground transmission to keep pace with the ever-increasing overhead transmission voltages.

ACKNOWLEDGMENTS

Grateful acknowledgment is made to the many suppliers and Anaconda staff who contributed to design, construction, procurement, and installation of the laboratory and its equipment; and especially to George Bandre, L. L. Carter, E. A. Casey, W. G. Devenish, L. C. Ebel, E. D. Eich, W. C. Gingras, Bjorn Jore, E. O. Juhlin, H. E. Thompson, J. J. Walker, R. J. Westcott, and A. E. Widmer.

Also, gratitude is expressed to the several domestic and overseas operators of laboratories who freely permitted visits and discussion with their staffs.

A Speed-Setting Transducer

N. G. ALVIS
MEMBER AIEE

THE DEMAND for better control in modern complex electric power systems calls for better load- and frequency-control equipment. One such supplementary device is the Woodward rapid load control auxiliary, as used on hydraulic turbine governors.

This auxiliary provides a simple, effective way of applying high-speed continuous-type electric control signals to the governor for moving the wicket gates at their fastest allowable speed. The output of the auxiliary is superimposed on the other movements in a standard governor. The operator can, at any time, override the load control auxiliary with the regular governor controls, if desired.

The rapid load control auxiliary consists of a magnetic amplifier and speed-setting transducer plus levers to introduce its movements into the existing governor mechanism.

A schematic of the speed-setting transducer is shown in Fig. 1. It is a forced-balanced system with a differential-type servo piston. The position of the servo piston is proportional to the force on the pilot-valve plunger. The controlling force on the pilot valve is a force resulting from the action of the permanent-magnet armature in the electromagnetic field of the control coil. This controlling force is proportional to the input signal current in the control coil. Thus, servo piston position is proportional to input signal.

One adjustment on the speed-setting transducer is the servo piston adjusting screw. It provides a means of adjusting the position of the output servo piston at zero current or any selected value of input current.

The compensating spring is required because of the negative scale of the armature magnet. This scale results from the tendency of the magnet, when displaced slightly from center and with no current in the coils, to move to the end of its stroke. The compensating spring is compressed to provide a preload force to balance a similar preload force contributed by the restoring spring.

The restoring spring, as the name implies, restores the pilot valve as a result of servo piston movement. The scale of the restoring spring and the controlling force on the pilot-valve plunger attributable to the input signal establish the stroke of the servo piston.

In addition to its controlling feature, the speed-setting transducer must also be capable of locking the servo piston in position in the event of signal failure or other system failure. When such a failure occurs, the solenoid-operated valve is de-energized and supply pressure oil is diverted from the pilot valve and differential servo piston to the locking piston. While the transducer is locked, the governor reverts to its traditional method of operation. The servo piston is held in the position existing at the time of failure. The accuracy with which the servo piston is locked is greater when the servo piston moves at a slower rate. Control of the rate of movement of the servo piston is accomplished by means of the throttling screw in the control line. However, because it is desirable to operate the gates at their fastest allowable speed, the timing of the servo piston must be kept as fast as the gate timing.

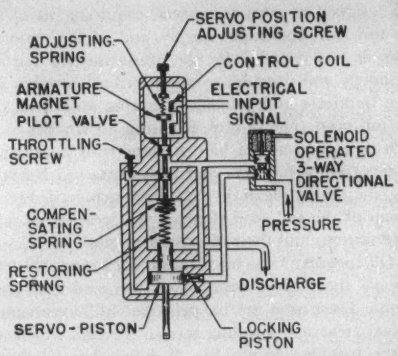


Fig. 1. Schematic diagram of speed-setting transducer.

The output of the speed-setting transducer is superimposed on other governor movements in such a manner that the action resulting from a change in transducer output is exactly the same as the action of changing the speed setting on the governor. The rapid load control auxiliary can be installed on a standard hydraulic turbine governor by replacing three standard parts and adding two levers.

The rapid load control auxiliary, when applied to a generating unit with speed droop in a large system, provides a simple, effective way of changing load rapidly by changing speed setting rapidly. The speed-setting transducer itself (plus minor governor modifications) is easily adaptable to existing governors, making conversion of present equipment highly desirable. Because of the nature of the device, it suggests potential applications in all types of auxiliary controls, one of which is tie-line load control. Current developments in load- and frequency-control equipment also suggest its possible use on some types of primary controls.

Digest of paper 58-932, recommended by the AIEE System Engineering and Power Generation Committees and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting and Air Transportation Conference, Buffalo, N. Y., June 22-27, 1958. Published in AIEE *Power Apparatus and Systems*, Dec. 1958, pp. 1079-82.

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Integrated Mobile Microwave Communications System

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A COMMUNICATIONS SYSTEM has been designed to meet the special requirements of modern toll road operations simply, and within reasonable costs. It was installed for the Massachusetts Turnpike Authority and provides communications between turnpike buildings and vehicles operating anywhere along the toll road right-of-way. By using microwave to link each of the seven vhf base stations with maintenance centers, police barracks and administration headquarters, the desired flexibility has been achieved. Fig. 1 is a map of the toll road showing the location of microwave stations and their interconnections.

"Off turnpike" vhf base station sites were selected to provide the desired coverage of the road and its environs. These sites are on principal hills commanding a good view of the rolling terrain through which most of the turnpike winds. Fig. 2 shows the vhf channel arrangement. Chicopee Falls is the central dispatch point where all base station and auxiliary control circuits are terminated in a control console. The operators there intercept all vhf calls and may connect the parties together by means of a specially designed cordless switchboard. There are two independent voice channels through the console switchboard which permits operating the eastern and western sections of the road as separate vhf systems.

A single 150-mc frequency pair is shared by both maintenance and police activities, with selective calling of mobile units and interchanges providing adequate security. Separate tones are provided for calling police, maintenance, interchanges, individual administrators, and "all call."

Because there is overlapping vhf coverage, a mobile may be received on two or more base-station receivers. Therefore, a selection device is used which permits only one receiver output to modulate the system—the one with the best signal. The audio from any other receiver is muted until the system is released by the mobile making the call.

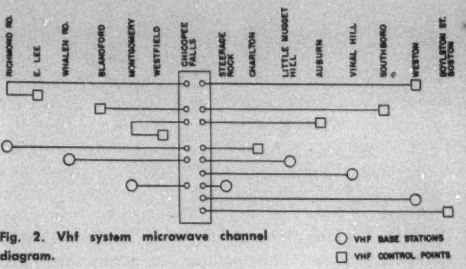

Fig. 2. Vhf system microwave channel diagram.

At the present time, the vhf traffic load totals about 17,000 calls per month, or one call every 2½ minutes. This will increase during the summer months.

Besides providing independent voice channels for each vhf base station and control point, the microwave carries telephone and teletype circuits between all maintenance centers, police barracks, and administrative headquarters.

The single 2,000-mc r-f carrier is modulated with pulses from time-division multiplex equipment. Each pulse in a frame contains a sampling of the audio information on its associated voice circuit. Stand-by duplicate r-f equipment is provided on all main-line circuits and an alarm channel provides an indication at Chicopee Fall of the condition of each station.

Telephone channels are "party line" with dial selective ringing. Dial pulses are transmitted via microwave and step a selective ringing unit at each station. Only the selector associated with the number dialed responds by ringing an extension.

The teletype system consists of five machines connected together in a "loop." A message typed on any one is received on all machines including the sender.

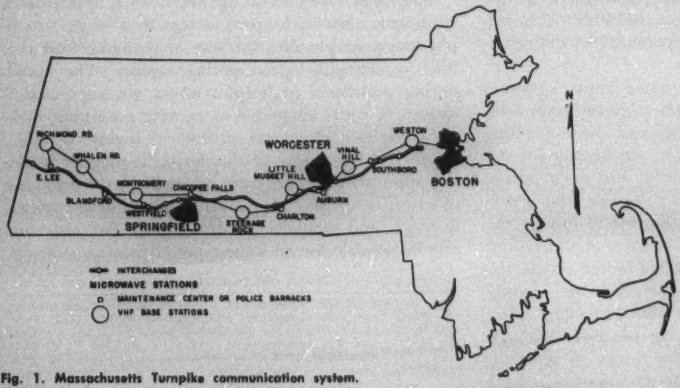

Fig. 1. Massachusetts Turnpike communication system.

Digest of paper 58-815, recommended by the AIEE Radio Communication Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting and Air Transportation Conference, Buffalo, N. Y., June 22-27, 1958. Published in AIEE *Communication and Electronics*, Nov. 1958, pp. 703-07.

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International Standardization of Static Power Converters

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A discussion of the role of Technical Committee no. 22 (TC-22) of the International Electrotechnical Commission (IEC) in evolving international standards for static power converting equipment.

STANDARDIZATION of static power converting equipment is important because such equipment finds application in nearly every industry where electric power is used. Technical Committee no. 22 (TC-22) of the International Electrotechnical Commission (IEC) has responsibility for international standards recommendations covering static power converting equipment. The work of the Committee was initiated in 1935 at Scheveningen, The Netherlands. Except during World War II, the main committee or its subcommittees have been meeting almost annually to consider and decide upon various recommendations. Good progress has been made and the Committee has a program which will require several years to complete. It is the purpose of this article to tell something of the objectives, organization, work already done, and future plans.

The primary objective of IEC is to unify national electrotechnical standards by preparing recommendations for standardization which can be followed by interested nations in their own national standards. IEC recommendations may also be adopted or referred to by nations who may not have developed their own standards. They require the approval of at least four fifths of the national committees. This approval is obtained by circulating a draft specification which a technical committee believes will find the widest possible international acceptance to the nations under the so-called "Six-Months Rule." The nations are permitted 6 months to study the document and vote. It should be emphasized that compliance with international recommendations is not mandatory for any participating nation. However, it is desirable for each nation to follow IEC recommendations in their national standards and practices insofar as possible.

PAST ACCOMPLISHMENTS

THE MERCURY-ARC CONVERTER was relatively new when TC-22 began work in 1935. Mercury-arc technology was changing rapidly. Glass and metal multianode valves were widely used. Single anode excitron and ignitron valves were emerging. Application was broadening explosively. These were probably the reasons why it was necessary to hold so many meetings, nine in all, before international agreement was reached at Philadelphia, Pa., in 1954.

The time was not wasted, however, for an exceptionally comprehensive and useful document was developed entitled "Recommendations for Mercury-Arc Converters," IEC Publication 84, issued in 1957. Aside from its value in promoting and unifying national standards in various countries, Publication 84 is an authoritative and worthwhile reference on the subject for other purposes. Anyone interested in the subject of mercury-arc converters ought to have this 95-page publication in his library.

Publication 84 contains five sections: the first is "General," treating such subjects as terminology, definitions, circuitry, service conditions, tests, and letter symbols; the second entitled "Valves" touches on service conditions, temperature limits, measurement of losses, and insulation of valves; the third topic, "Transformers and Reactors," covers loss measurement and insulation tests insofar as they are special for converter applications and not covered by other existing transformer and reactor specifications; the fourth section deals with the "Converter" proper (i.e., the combination of rectifier, transformer, and other auxiliaries necessary to make operative units) including rating classifications, over-all efficiency, power factor, regulation, harmonics, etc.; and the fifth section is a short one dealing with "Tolerances."

To some extent, the work on mercury-arc converters crystallized the objectives of the members of the Static Power Converter Technical Committee. There is general agreement that international recommendations in

Fig. 1. Large silicon rectifier installed in an electrochemical plant.

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this field should establish the necessary vocabulary and yardsticks to facilitate commerce by establishing uniform means of evaluating tenders. The phases of standardization aimed at savings through duplication requiring agreement on rating sizes, dimensions, and interchangeability are left to national standardizing bodies, where revisions can be made easily and quickly when there are technological changes.

The work on semiconductor rectifiers was started in 1955 in London, England, by a new subcommittee known as SC 22-2. It was then too early to anticipate the great impact of the monocrystalline rectifiers, germanium and silicon, on industry; and it was first planned to cover both polycrystalline and monocrystalline semiconductor power converting equipment in one document. By the time of the next meeting of SC 22-2 in Munich, Germany, in 1956, the members began to see the desirability of separating the work on polycrystalline and monocrystalline semiconductors and preparing two sets of recommendations. The British delegation offered to prepare a draft proposal on monocrystalline semiconductors at Munich, an offer which was accepted. Consequently, the work of SC 22-2 was separated during the 1957 Moscow, USSR, meetings. The monocrystalline draft specifications were considered during the first week and the polycrystalline document during the second week.

Such good progress was made on the polycrystalline recommendations that the committee decided to recommend submission of the final draft as revised at Moscow to the national committees for approval. Document "IEC Recommendations for Polycrystalline Semiconductor Rectifier Stacks and Equipments" dated May 1958 has been approved under the "Six Months' rule." When issued, this document will form the basis for the second official IEC publication by TC-22. In all likelihood, this will conclude IEC work on polycrystalline type semiconductors.

The content of the 55-page document on polycrystalline semiconductor stacks and equipments is very similar to that of Publication 84. The recommendations pertaining specifically to copper-oxide and selenium stacks are perhaps somewhat more penetrating than the similar work on valves in Publication 84. This was necessary because the sale of copper-oxide and selenium stacks as separate components is much more common than the sale of separate valves.

Fig. 2. Pumpless mercury-arc rectifier for steel mill main drive.

Fig. 3. Installation photograph of pumpless mercury-arc rectifiers for electrochemical service.

These recommendations covering copper-oxide and selenium stacks will probably prove to be the only case where TC-22 directs special attention to components separate from converting equipment. If need for a similar kind of work ever develops in the future, the project would be referred to TC-39 for action.

The past work of TC-22 has achieved more than the completion of the two documents described. Many of the delegates have attended the meetings regularly for many years and, thus, continuity of service has been established which facilitates more rapid progress. The delegates have learned how to work with one another, co-operatively and without restraint, to reach quick agreements. There is now common understanding of the general and specific objectives of the committees. A style and content for TC-22 documents has evolved which the delegates seem inclined to follow.

FUTURE PROGRAM

THE TASK immediately ahead for the committee is the work on monocrystalline semiconductor power converting equipment in which international interest is intense. A total of 55 delegates from 14 nations—Belgium, Czechoslovakia, France, West Germany, Hungary, Italy, Rumania, Sweden, Switzerland, United Kingdom, U.S.A., USSR, Yugoslavia, and China—participated in the work in Moscow. This year, nearly 40 delegates from the same countries and others worked together again on monocrystalline recommendations for 4 days, 2 in Ludvika and 2 in Stockholm, Sweden.

Monocrystalline semiconductor technology is new and in a state of flux. Within the past 5 years, industry has seen the introduction of first, germanium; next, silicon; and within the past few months, controlled silicon, high-current, commercial semiconductor products. Now that semiconductors can be controlled, they are functionally equivalent to grid-controlled, mercury-arc valves. This latest development may tremendously expand the fields of application of semiconductors. One

might wonder whether work on monocrystalline semiconductor converting equipment is not premature under the circumstances. The answer to this question is that there was an insistent demand from most of the nations participating in the work of TC-22 for guidance in their national standardization work in this area. In a way, the work of TC-22 on monocrystalline converters is an interesting experiment by IEC in trying to unify national standards before the nations start off in different directions.

During the meetings in Sweden, the delegates came to realize that it was too early to complete an official IEC publication because of the rapid changes going on in monocrystalline technology. It was agreed furthermore that little more of substance could be added to the present draft specifications for several years. Therefore, it was decided to finish a draft of "preliminary recommendations" in 1959. These will be distributed among all the nations simply as a "Secretariat Document." It was felt that such a document would provide much needed guidance to the nations at once on an informal basis. Work on monocrystalline semiconductors can then be suspended temporarily, allowing the committee to work on other pressing static power converter problems. The work on monocrystalline converters can be resumed at a future date after the technology has developed sufficiently and solidified.

A number of nations have wanted to extend the Committee's work on mercury-arc converting equipment. Publication 84 deals comprehensively with rectification, but has little to say about inversion. The West German National Committee offered in 1957 to prepare a preliminary draft proposal on inverters for distribution and study by the other national committees. Their proposal was received during the meetings in Sweden. These inverter recommendations may ultimately take the form of an appendix to Publication 84. The committee was not able to consider the German proposal during the 1958 meetings but recommended that the national committees send their comments to the Swedish secretariat.

The Soviet delegation agreed to prepare draft proposals for the next meetings of TC-22 on: reversible electrical valve drives; high-voltage units (up to 15,000 volts); traveling units, i.e., for locomotives and motor coaches; frequency changer units; terms and definitions for the previously mentioned converters; normalization of failure limits for different converters; and normalization of heat tests for special tropical conditions.

To carry forward its future program, TC-22 decided at its final meeting in Sweden that meetings of SC 22-2 should be planned during 1959 at some as-yet undetermined place in Europe to conclude the present work on monocrystalline semiconductor converting equipment. The West German and Soviet draft proposals mentioned will be considered next. In the meantime, the West German and Soviet proposals will be circulated to the nations for study and comment. Thus, it is anticipated that advanced work on mercury-arc converters will be renewed in 1960.

ADVANTAGES OF IEC RECOMMENDATIONS

The extensive work of TC-22 and its subcommittees takes much valuable time of its delegates, its officers, and particularly its secretariats. Expense of attending the annual meetings is not inconsequential. It is a fair question to ask, "What are the benefits?"

Of course, one of the most obvious and perhaps the best answer to this question is that the recommendations facilitate business and commerce in static power converters. They are written in such a way that users may refer to them for guidance in writing specifications for power converting equipment which they may intend to purchase. Even more important, these are suitable yardsticks to determine acceptability and compliance when evaluating tenders. Misunderstandings that can lead to costly mistakes can be avoided if users' and manufacturers' specifications adopt the vocabulary and stipulate converter performance in a way that conforms to IEC rules. This is, of course, of tremendous benefit to both in carrying out mutually profitable business relationships.

More than 30 years ago, H. W. Whitney, then chairman of the American Engineering Standards Committee, characterized standardization as "the habit-forming process in industry which relegates the problems which have been already solved to their proper place; namely, to the field of routine, and leaves the creative faculties free for the problems that are still unsolved." This answers a criticism which is fortunately heard less and less these days, that standardization obstructs technological development. In fact, many thoughtful engineers are of the opinion that modern technology is founded on standardization. Standards clarify and simplify the scientific basis for engineering and provide a dependable pattern for its extension, both in innovation and broadening applications.

That standardization improves productivity and reduces costs has been proved and is widely accepted. This benefit applies as much to power converters as it does to other products.

Richard Viewig, the fourth IEC Charles LeMaistre Memorial lecturer, in the summer of 1958 spoke in Stockholm on "Measuring, Standardizing, and Producing." For those who are in doubt about standardization, Mr. Viewig treats the subject in both a practical and philosophical way that makes the lecture well worth reading. One of his thoughts bears quoting as the conclusion of this report:

> "During their development from the discussion of technical facts among experts, the idea of what is acceptable grows and finally leads to a balance, even when in the beginning there seemed to exist no common ground among the participants."

This is a concept of standardization which grows more powerful as it progresses from the national to the international level. It is something which has happened in large measure in the work of TC-22.

Synthesis of Control Systems

C. R. HAUSENBAUER

G. V. LAGO
MEMBER AIEE

FEEDBACK CONTROL SYSTEM DESIGN is most effective when both steady-state and transient performance specifications can be realized. One approach, synthesis, proceeds from a set of closed-loop specifications to an appropriate open-loop system which, upon closure of the feedback path, satisfies the specifications. Almost without exception, a compensation network must be used in conjunction with the fixed portion of the system $G_2(s)$. In many cases it is desirable that the compensation network consist of resistance and capacitance elements. To be *R-C* realizable, the poles of the transfer function describing the compensation network must be simple on the negative real axis, the origin and infinity excluded, i.e., its pole-zero excess must be equal to or greater than zero.

Terminology pertinent to the proposed method of synthesis is indicated in Fig. 1. Distinctive features of the method are

1. Formulation of a closed-loop transfer function $C(s)/R(s)$ from a set of specifications not dependent upon the pole-zero excess of $G_2(s)$.
2. Elimination of graphical procedures to determine the poles of the open-loop transfer function $G(s)$.
3. Assurance that the nonzero poles of $G(s)$ are always on the negative real axis.
4. A criterion for placing a pole of $G(s)$ at a particular frequency to obtain a simplified compensation transfer function $G_1(s)$.
5. Incorporation of the $G_2(s)$ pole-zero excess requirement in a modified compensation transfer function $G_1'(s)$ as the final step of the procedure.
6. In most cases, elimination of steady-state and transient response verification of the closed-loop specifications.

Of these features, the first four are realizable with the simple idealized system in Fig. 1 (A), idealized in the sense that $G_1(s)$ is not required to have a pole-zero excess equal to or greater than zero. The appropriate open-loop Bode plot is identified as $|G(j\omega)|$ in Fig. 1 (C). The last two features are realized with the modified system in Fig. 1 (B), in which the modified compensation transfer function $G_1'(s)$ has the necessary pole-zero excess for it to be *R-C* realizable. In this case, the appropriate open-loop Bode plot is identified as $|G'(j\omega)|$ in Fig. 1 (C). The deviation of the two Bode plots at high frequencies represents the action of the poles that must be added to $G_1(s)$, as a consequence of the pole-zero excess of $G_2(s)$, for $G_1'(s)$ to be *R-C* realizable. The higher the frequency at which the deviation of the curves occurs, the smaller will be the effect of the added poles on the closed-loop performance of the system.

A closed-loop transfer function of the form

$$\frac{C(s)}{R(s)} = \frac{\omega_n^2 p_3}{z_1} \frac{s + z_1}{(s + p_3)(s^2 + 2\zeta\omega_n s + \omega_n^2)} \qquad (1)$$

is capable of incorporating the features enumerated while realizing an extensive variety of transient and steady-state specifications such as (1) overshoot, (2) rise time, (3) delay time, (4) bandwidth, and (5) velocity constant. For convenience, equation 1 was normalized with respect to ω_n by making a change of variable $p = s/\omega_n$. Typical sets of curves suited to the synthesis procedure as proposed were prepared in normalized form. These curves relate the previously mentioned specifications to both open-loop and closed-loop poles and zeros.

The proposed method is direct and quick, and is sufficiently accurate for many situations normally encountered when unity-feedback is applied to a minimum-phase type *1* system. Simplicity of the method is achieved by (1) maintaining a design value of velocity constant and (2) delaying consideration of the pole-zero excess of $G_2(s)$ until the final step of the procedure. As a consequence, the method is essentially independent of the complexity of $G_2(s)$, and except in a marginal situation in regard to transient specifications, the necessity of factoring high-degree characteristic equations is avoided. Accomplishing (1) and (2) above when a pole is added to assure an *R-C* realizable compensation transfer function generally results in slight increases in both closed-loop overshoot and bandwidth.

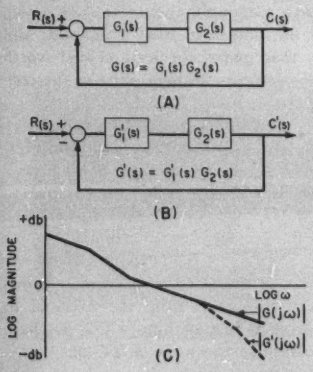

Fig. 1. System block diagrams and Bode plots illustrating the proposed method of system synthesis.

Digest of paper 58-797, "Synthesis of Control Systems Based on an Approximation to a Third-Order System," recommended by the AIEE Feedback Control Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting and Air Transportation Conference, Buffalo, N. Y., June 22-27, 1958. Published in AIEE *Applications and Industry*, Nov. 1958, pp. 415-21.

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Thermosiphon Flow in a Model Transformer Oil Circuit

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THERMOSIPHON COOLING of oil-immersed transformers has been in use for many years, and cooling tubes and radiators in standard configuration may be applied to transformers with confidence. In the development of new cooling equipment, however, the performance and efficiency of new shapes and arrangements are determined empirically. The theoretical analysis of thermosiphon flow is quite complicated. Actually, although it may be used qualitatively in many cases, the theoretical approach is directly applicable only to idealized circuits, and the basic assumptions concerning modes of flow, for example, must be checked experimentally.

A better understanding of the temperature distribution, flow patterns, and velocity profiles would aid materially in the design of improved cooling equipment. The tests described herein were designed to obtain data on the characteristics of thermosiphon oil flow in transformers.

Fig. 1 shows the model oil circuit used in these tests. It consisted of a small tank and cooler assembly having Plexiglas inserts at strategic locations to allow visual observation of oil flow patterns, with movable thermocouples arranged to measure temperature distribution in the tank and temperature profiles in the cooler tube. The velocity patterns were observed by timing the passage of suspended particles between reference lines. The heating coil elevation was varied to correlate temperature distribution with coil elevation.

The flow of cooling oil in the cooler tube occurred in a thin layer adjacent to the tube wall. In the upper half of the cooler, the central column of oil appeared unstable, moving generally upward. At the middle window of the cooler tube, with the heating coil at the lower elevations, the oil flow broke into turbulent, cellular eddying. This was not the turbulence of a high Reynolds number, inasmuch as the flow was very slow. When the heating coil was raised, the turbulent flow pattern diminished until, at an elevation of 13 inches, no movement could be observed in the central oil column.

The oil entering the tank from the bottom header is not at a uniform temperature. In its horizontal flow it becomes stratified, so the oil temperature may vary several degrees from top to bottom of the bottom header. When measuring bottom oil temperature in the coolers, therefore, this fact must be considered in positioning the detector.

Above the core and coils in a transformer, the oil is all essentially at a uniform temperature, especially when there are no heat sources, such as extensive bus work, present. In this region of very low temperature gradients, the eddying effects of oil flow out of the coil ducts and down along the tank wall are not damped, and their effect is noticeable in the slow, random movement of this body of oil.

There is a definite correlation between relative elevation of heat source and heat sink and the top-to-bottom oil temperature difference. Good oil circulation is obtained when the transformer core-and-coil assembly is positioned low in the tank. Transformer designers strive for this condition. When the heat source is high in the tank, oil circulation is slow, resulting in high top-to-bottom oil temperature difference and a high hot-spot rise. This is confirmed by these tests.

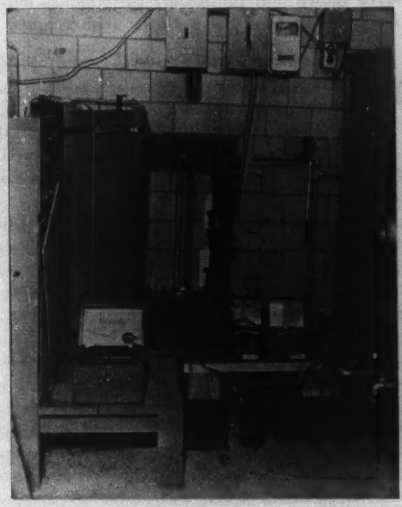

Fig. 1. Test model.

The oil which is active in heating and cooling is only that oil in a thin film adjacent to the hot and cool surfaces. Recent developments in cooling equipment for certain lines of transformers indicate a trend toward the thin, flat-walled cooler. Although evidently intended primarily as an aid to maintenance—being easier to clean and repaint—the new cooler designs might also be justified on the basis of eliminating a useless central oil column which contributes only excess weight.

Digest of paper 58-780, recommended by the AIEE Transformers Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting and Air Transportation Conference, Buffalo, N. Y., June 22-27, 1958. Published in AIEE *Power Apparatus and Systems*, Dec. 1958, pp. 973-77.

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An Investigation on Elastic Sheath Pressure Cables

N. KLEIN

An investigation has been conducted on cables with elastically deforming sheaths, which have been designed to dispense with the conventional bulky and expensive external means of maintaining pressure in high-pressure cables. Results have shown that satisfactory performance may be expected from these elastic sheath cables.

PRESSURE in high-voltage pressure cables is maintained by oil reservoirs, gas-filled pipes, or other external means, with the result that these cables are bulky and expensive. For this reason, many pressure cable designs dispensing with external means have been proposed.

Fig. 1 shows cross sections of the simplest of such cables. They resemble solid-type cables, but have sheaths made of an elastically deforming alloy. Deformation of these sheaths produces the pressure. The cable at no load is filled with oil at a pressure p_0. Owing to the larger thermal expansion of cable interior than of sheath, strains in the sheath increase with load. It is essential that on maximum load the largest strain in the sheath, ϵ_{mz}, should be smaller than the proportionality limit and the applicable fatigue limit of the alloy. Should the proportionality limit be exceeded, permanent deformation would arise and the pressure would drop below p_0 on subsequent no-load periods, endangering the electrical safety of the insulation.

It is known that circular elastic sheath cables do not perform satisfactorily because permanent sheath deformations are produced by the temperature rise at relatively small loads. The performance of noncircular cables, however, heretofore has been unknown.

In this investigation, the temperature-rise limit of noncircular cables was calculated by consideration of the work done on the sheath by the pressure and by determination of the strains in the sheath. Two simple relations resulted for optimum design valid for all cables in Fig. 1. The first gives the highest permissible temperature rise of the conductor Θ

$$\Theta = \frac{c_\theta K}{\alpha_r} \sqrt{\frac{\epsilon^3_{mz} E}{(1-\mu^2)\, p_0}}$$

and the second the core radius sheath thickness ratio $(r/t)_\theta$ at which Θ is obtained:

$$\left(\frac{r}{t}\right)_\theta = c_{r/t} \sqrt{\frac{\epsilon_{mz} E}{(1-\mu^2)\, p_0\, k_4}}$$

Here E and μ are Young's modulus and Poisson's ratio of the sheath alloy, respectively; α_r is a thermal expansion coefficient of the cable; c_θ and $c_{r/t}$ are cable constants; and K and k_4 are correction factors. Values of c_θ, $c_{r/t}$, K, and k_4 vary with cable shape and may be tabulated.

Fig. 2 shows $\Theta = f(\epsilon_{mz})$ for 3-core flat and triangular cables, when $p_0 = 7$ pounds per square inch. Under identical conditions, Θ of flat cables is about twice that of triangular cables. Highest temperature-rise limits of customary pressure cables is 70 C and this can be ob-

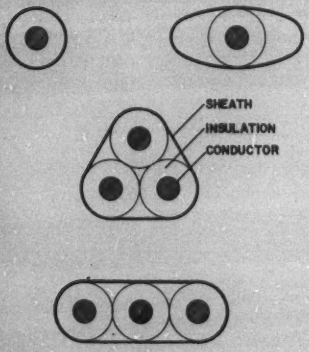

Fig. 1. Cross sections of elastic sheath pressure cables.

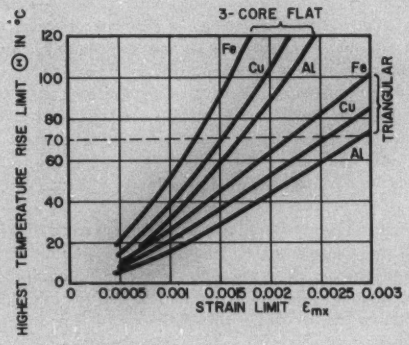

Fig. 2. Highest temperature-rise limit of elastic sheath 3-core flat and triangular pressure cables as function of the strain limit, for Al, Cu, and Fe alloy sheaths ($p_0 = 7$ psi).

Condensed text of conference paper CP58-864, presented at the AIEE Summer General Meeting and Air Transportation Conference, Buffalo, N. Y., June 22-27, 1958. Recommended for publication by the AIEE Insulated Conductors Committee.

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tained with elastic sheath 3-core flat cables when ε_{m2} equals approximately 0.0015 and with triangular cables when ε_{m2} equals approximately 0.0025. Many alloys have such proportionality limits already in semihard states; highest proportionality limits reach 0.006 for beryllium copper.

The mechanical and thermal performance of these cables should thus be satisfactory. Electrically similar behavior to that of oil-filled cables is expected. The essential problems of these cables are sheathing, transport, and laying. Recent developments indicate that sheaths might be produced by extrusion or by welding a flat strip bent around the cable. Soft, annealed alloys might be used for sheathing. After cable laying, the sheath would be hardened by work hardening or by precipitation hardening on heat treatment.

Although the technological problems are seemingly difficult, it is hoped that the simplicity and smallness of these pressure cables constitute sufficient inducement for practical investigations.

Engineering Aspects of TASI

KENNETH BULLINGTON J. M. FRASER

Because of the normal pauses between sentences, words, and even syllables, a talker actually uses a telephone circuit only about 35% of the time. TASI takes advantage of this fact by interpolating additional channels into existing groups of channels, thus greatly increasing the usefulness of transatlantic and other expensive cable systems.

FOR MANY YEARS telephone people have been intrigued with the idea of making use of the idle time during a telephone call. TASI (an abbreviation for Time Assignment Speech Interpolation) is a high-speed transmission and switching system based on the principle of using the free channel time to interpolate additional talkers. Although TASI requires considerable terminal equipment, it can approximately double the usefulness of long expensive channels such as the deep sea submarine cable systems. The first speech interpolation system is expected to be placed in service during 1960 on the first transatlantic telephone cable system between London and New York, which was opened for service in September 1956.

The basic principles of TASI are old. An extensive investigation of the feasibility of speech interpolation systems was conducted in 1946 and 1947 by A. C. Dickieson, P. G. Edwards, and others. An experimental model was demonstrated in 1950 by A. E. Melhose, and this was later extended and improved by R. L. Carbrey.

In a normal two-way conversation, each talker ordinarily uses the circuit for only about half of the time. In addition, the circuit may not be used momentarily while the operator is trying to get the right people together, or while an individual comes to the phone or takes the normal pauses between sentences and even syllables. All of these gaps add up to a substantial amount of free time. Measurements on working circuits shown in Fig. 1 indicate that the average activity (percentage of time that energy above a very low threshold is transmitted in one direction) is no more than 35 to 40% of the time that the circuit is busy at the switchboard. Since long distance circuits use separate pairs of wires or separate carrier channels for the two directions of transmission, it follows that, on the average, each one-way channel is free for 60 to 65% of the time.

An attempt to interpolate two or more independent conversations on a single channel would create considerable delay and mutual interference, because the probability of two talkers wanting the same channel at the

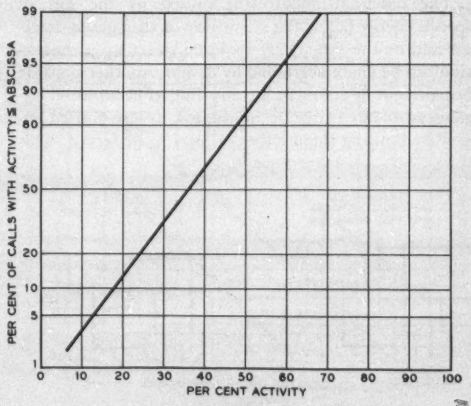

Fig. 1. Measured activity distribution on transatlantic calls.

Full text of paper 59-70, presented at the AIEE Winter General Meeting, New York, N. Y., Feb. 1-6, 1959. Recommended for publication by the AIEE Wire Communication Systems Committee.

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same time is moderately high. However, when two or three dozen channels are operated as a group, these variations in individual activity tend to average out and the probabilities can be counted on to minimize the mutual interference to a point where there will be no noticeable effect on continuity of conversation. For example, even when all the channels are busy, at least one channel on the average is available for reassignment every L/c seconds where L is the average talkspurt length (which is somewhat less than 1 second) and c is the number of channels in the group.

A simplified block diagram for a TASI system is illustrated in Fig. 2 for one direction of transmission. An identical but independent arrangement is used for the opposite direction. Each of the n lines from the toll switchboard is equipped with a speech detector which is capable of recognizing the weakest speech within 5 milliseconds (msec) or less. When the speech detector on line 1 operates, the TASI switching network connects line 1 to an idle channel, say channel c, and then sends on that channel, a 10- to 15-msec coded signal which instructs the distant receiving terminal to connect that channel to listener line 1. Once a connection has been set up, it is maintained until someone else needs a channel, even though the person may stop talking in the meantime. A similar 10- to 15-msec coded signal is used for disconnect purposes, but this is sent over a separate channel reserved for this purpose in order to avoid interference to the listener.

When speech appears on any of the n lines, the speech must be recognized by the speech detector, which causes some clipping during the first few milliseconds. This type of clipping can be minimized by increasing the sensitivity of the speech detector. The sensitivity cannot be too high or it will operate too often on noise, which is undesirable because it increases the activity and hence reduces the TASI advantage. A compromise is needed to achieve minimum activity while maintaining satisfactory speech quality for even the weak talkers.

The potential impairment caused by the loss of speech energy below the sensitivity of the speech detector and by the time delay required to set up a connection can be made negligible by design. Another possible impairment is inherent in any line concentration arrangement but it can be minimized to any desired degree by limiting the number of lines to be served. This

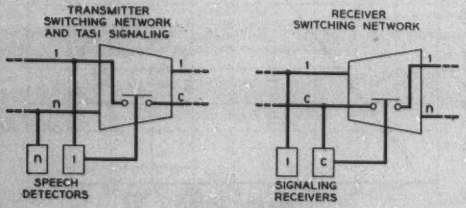

Fig. 2. TASI block schematic diagram.

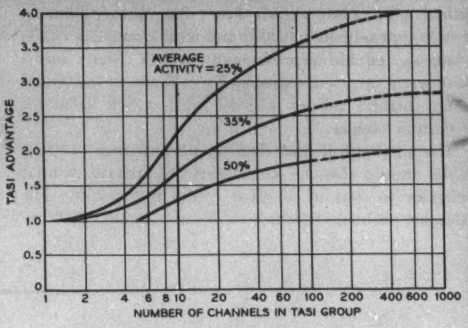

Fig. 3. TASI advantage for a freezeout fraction of 0.5%.

factor is the possibility that the number of individuals who are talking or starting to talk at a particular instant will exceed the number of available channels. For example, telephone subscribers on a party line must share time with their neighbors on a single pair of wires leading to the central office. In addition, all trunk lines between two or more central offices may occasionally be busy and a call coming in at that instant will experience some delay. In a similar manner, TASI may occasionally be overloaded by an unusually large number of simultaneous talkers. In this case, however, the information cannot be delayed and any failure to make an almost instantaneous connection results in a loss of speech transmission (called a freezeout) until a channel becomes available. It appears that the effect on transmission quality is negligible as long as the percentage of lost speech (freezeout fraction) is less than 0.5%.

During periods of light traffic, the system operates essentially the same as without TASI, and hence there can be no TASI impairment. However, as the load increases, the amount of switching and possible impairment increases. The problem is to limit the number of busy lines to a point where the resulting impairment is not noticeable to the average listener and is not objectionable to the more critical listener.

The number of circuits that can be made available for service at the toll switchboard (for a freezeout fraction of 0.5%) is greater than the number of physical channels by the TASI multiplying factor shown in Fig. 3. As the number of channels in the group increases, the number of potential conversations approaches a limit set by the reciprocal of the average activity. It will be noted that a 36-channel group, such as that available in present submarine cable systems, achieves a substantial TASI advantage, but that the application of TASI to only a dozen channels or less is much less attractive. For an average activity in the range of 35 to 40%, it appears that the use of TASI on a 36-channel group can at least double the number of available circuits and still maintain good quality.

The average number of simultaneous talkers, np, is

the product of the number of busy lines n multiplied by the average activity p. When the average number of simultaneous talkers is approximately equal to the number of channels c, there is a 50% chance that a new talker will be frozen out momentarily. This does not mean that 50% of the speech is lost, but there is noticeable impairment. In order to allow for variations around the average and to achieve satisfactory quality, the average number of simultaneous talkers, np, should be limited to a value that will satisfy the following approximate condition: $np + \sqrt{np} \leq c$.

This approximate expression is based on a more exact derivation given in the appendix. When this criterion is met, only a small percentage of the connections will experience any degree of freezeout except that required for the connect signaling code.

The expected freezeout fraction is shown in Fig. 4 as a function of the number of busy lines working on 36 physical channels for a talker activity of 30 to 40%. Listening tests have shown that a freezeout fraction of 0.1% is barely perceptible by a critical listener. A value of 0.5% is noticeable to the critical listener, but ordinarily is not apparent to an average listener who is intent on understanding a message. A value of 2% would be somewhat objectionable and a value of 5 to 10% would be definitely objectionable.

The average length of freezeout is roughly proportional to L/c, where L is the average talk-spurt length and c is the number of channels. The average talk-spurt length for TASI purposes depends not only on the characteristics of speech, but also on the sensitivity, operate time, and hangover of the speech detector. In addition, it depends on the number and duration of bursts of noise and echoes on the circuit. A typical measured value of effective talk-spurt length is about 0.6 second. Measurements of speech alone indicate a median talk-spurt length of about 0.6 second and a mean length of 1.5 to 1.8 seconds.[1]

The probability that a talk-spurt will be clipped longer than any specified value is shown on Fig. 5 for a 36-channel system with an effective talk-spurt length of 0.6 second. First of all, the chart shows that a 15-msec clip occurs for TASI signaling each time a new connection is needed. During the busy hour, this may occur on almost every talk-spurt, but the number of operations will be reduced considerably in nonbusy hours. The three lines sloping toward the right represent three different freezeout fractions. For example, the middle curve labeled 0.5% indicates 0.5% of the talking time has been lost because a channel was not available. In this case, about 6% of the talk-spurts are frozen out more than the 15-msec signaling time and 1% of the talk-spurts are frozen out for 80 msec or longer. A freezeout longer than 80 msec can be expected about four times during an average 10-minute call. For comparison purposes, it is worth noting that the average syllable length is about 125 to 250 msec. On the average, less than one talk-spurt in 10,000 will be frozen out for as long as 1/4 second, and this will occur only once in about 30 calls during the busy hour.

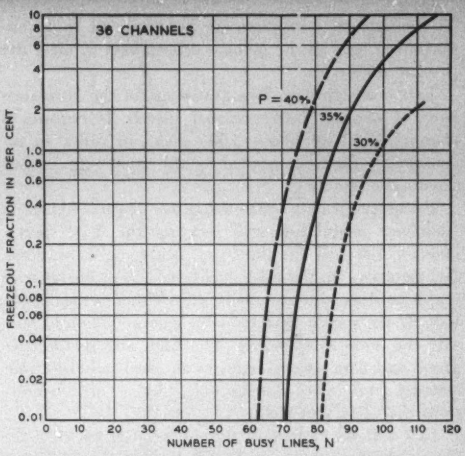

Fig. 4. Freezeout fraction vs activity and number of busy lines.

As mentioned earlier, a talker holds a channel until his speech detector indicates that he is finished talking and until someone else needs a channel. This is true on all but three of the available channels. One channel is reserved full time for disconnect and other control purposes and two talking channels taken at random are disconnected when possible in order that a channel will be instantly available for the next talker.

Switching from channel to channel during a conversation also causes some variations in circuit noise and net loss. It is expected that a little noise will be introduced in the receiving circuits in order to prevent a completely dead receiver during the silent intervals.

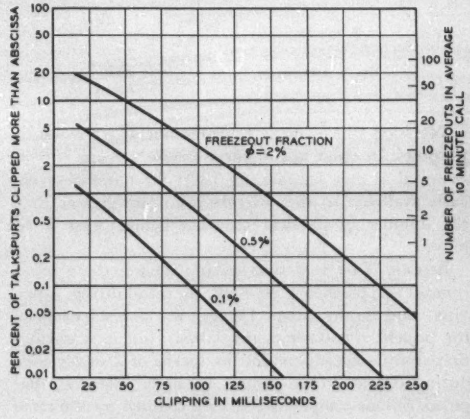

Fig. 5. Magnitude of clipping.

The variations in net loss are not expected to be important as long as the plant is maintained to meet the present objectives.

TASI is designed to take advantage of the characteristics of two-way conversational speech. It requires a channel width of about 3,000 cycles in order to accommodate the tones needed for the rapid connect and disconnect signaling.

Telegraph or data systems that use frequency shift or frequency modulation will lock up the TASI speech detector 100% of the time and, hence, be transmitted satisfactorily. On the other hand, the use of on–off telegraph or data systems will require either a means for locking the speech detector or a separate channel outside the TASI complement. The high activity of telegraph and data systems requires an essentially full-time channel, and hence reduces the number of conversations that TASI can yield.

TASI will be located in the 4-wire part of the telephone plant, as shown in Fig. 6. It requires that split-type echo suppressors be used to insure that echoes cannot seize an outgoing circuit at either end. Compandors, which are to be added to deep sea submarine cable systems on a channel-by-channel basis as required by noise conditions, are also compatible with TASI.

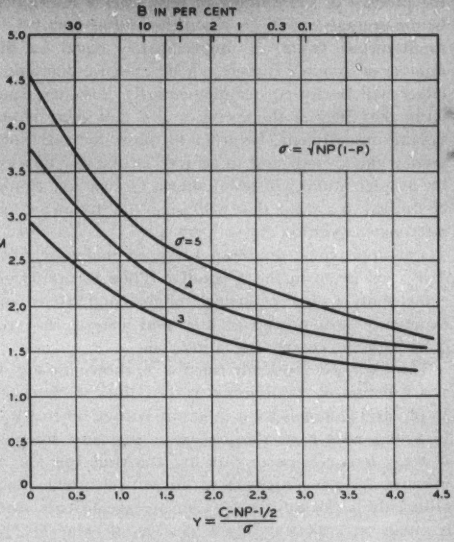

Fig. 8. Factor used in determining average length of freezeout.

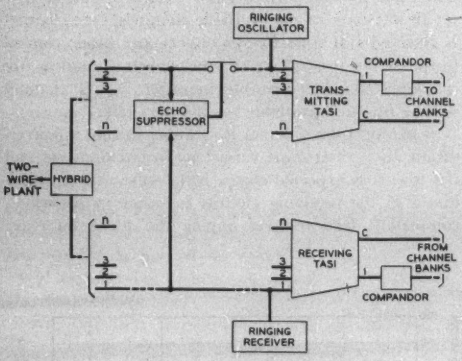

Fig. 6. Location in 4-wire telephone plant.

Provision will be made to switch out TASI for testing purposes. In order not to affect service, circuits will be removed as they become idle until the number of circuits available to the switchboard is no greater than the number of physical channels before TASI is removed.

Because TASI is a time-sharing device, there are a number of problems involved in transmitting supervisory and dialing pulses. TASI can work satisfactorily on the present ring-down manual basis, but it is obvious that continuous supervision by means of a steady tone during the idle time cannot be used. Likewise, dial pulses cannot compete for a TASI channel on the same basis as a talker, because TASI clipping would cause signaling errors. Various schemes using spurt signaling are being investigated for use when dialing over TASI is required.

Appendix

The TASI principle has been recognized for many years, and several individuals, including R. I. Wilkinson, have contributed to the mathematical analysis of speech interpolation. The following summary is based on a more complete analysis given in an unpublished 1953 memorandum by H. Cravis.

Assume that there are n independent talkers, each of whom has an average activity p competing with an individual test call (total number of talkers $= n + 1$). At any particular instant, the probability that the number of simultaneous talkers will equal or exceed c (where c is less than n) is given by the cumulative binomial distribution, $B_{(c,n,p)}$.

$$B_{(c,n,p)} = \sum_{x=c}^{n} \frac{n!}{x!\,(n-x)!}\, p^x\,(1-p)^{n-x} \qquad (1)$$

The probability of a freezeout lasting longer than t seconds is given by $B_{(c,n,\theta)}$ where $\theta = pe^{-t/L}$ for an exponential talk-spurt distribution [or $\theta = p(1-t/L)$ for a constant talk-spurt length].* In this expression L is the average talk-spurt length.

It can be shown that the average freezeout length (for an exponential talk-spurt distribution) is

* The assumption of an exponential distribution of talk-spurt lengths is the best simple approximation to the experimental data. The use of a constant talk-spurt length does not change the over-all result significantly.

$$t_p = L \sum_{k=c}^{n} \frac{1}{k} \frac{B_{(k,n,p)}}{B_{(c,n,p)}} \tag{2}$$

$$= \frac{L}{c} M \tag{3}$$

where

$$M = \left[1 + \frac{c}{c+1} \frac{B_{(c+1,n,p)}}{B_{(c,n,p)}} + \frac{c}{c+2} \frac{B_{(c+2,n,p)}}{B_{(c,n,p)}} + \cdots \right] \tag{4}$$

This series converges rapidly, so only a few terms are needed for sufficiently accurate results.

The fraction of the speech that is frozen out is

$$\Phi = \frac{t_p B_{(c,n,p)}}{L} = \frac{M}{c} B_{(c,n,p)} = \sum_{k=c}^{n} \frac{1}{k} B_{(k,n,p)} \tag{5}$$

Tables of the binomial distribution are available for accurate computations. However, in the range of interest to TASI this function is almost identical with the cumulative normal probability law, that is

$$B_{(c,n,p)} \approx \frac{1}{\sqrt{2\pi}} \int_{u=y}^{\infty} \exp\left[\frac{-u^2}{2}\right] du \tag{6}$$

where

$$y = \frac{c - np - \frac{1}{2}}{\sqrt{np\ (1-p)}}$$

In this expression the mean value is $np+\frac{1}{2}$ and the standard deviation is $\sigma = \sqrt{np(1-p)}$.

The probability that a given talk-spurt will be frozen out can be obtained from either equation 1 or equation 6 and is shown as a solid line in Fig. 7. For example, when $y = 1$, 16% of the talk-spurts will experience some degree of freezeout because there are more talkers than channels. Most of these freezeouts will last only a few milliseconds, so the percentage of speech that is lost is less than 16% by the ratio t_p/L.

By substituting $\theta = pe^{-t/L}$ for p in Fig. 7, it is possible to obtain the probability of a freezeout lasting longer than t/L. Typical values for a 36-channel system are shown in Fig. 5, for various values of the freezeout fraction Φ.

In all practical cases, the probability of freezeout is less than 50% and the cumulative binomial distribution and its approximation, the cumulative normal probability law, can be further approximated by the dashed line of Fig. 7, that is

$$B_{(k,n,p)} \approx \exp\left[-\frac{\sqrt{2}}{2} (1 + y_k + 0.6\ y_k^2) \right] \text{ for } B < 0.5 \tag{7}$$

where

$$y_k = \frac{k - np - \frac{1}{2}}{\sigma} = y_c + \frac{k-c}{\sigma}$$

This approximation, together with the omission in equation 4 of the factors $c/(c+1)$, $c/(c+2)$, etc. (which are less than but close to unity), leads to the following approximate expression for the factor M:

$$M \approx \sum_{k=c}^{\infty} \exp\left[-\frac{\sqrt{2}}{2} \frac{k-c}{\sigma} (1 + 1.2\ y_c + 0.6 \frac{k-c}{\sigma} \right] \tag{8}$$

The magnitude of M varies from about 1.5 to 3 or more, as shown in Fig. 8. This chart, together with equation 3, indicates that the average freezeout, when it occurs, is only about 1/10 to 1/20 of the average talk-spurt length in a 36-channel system.

By the use of equation 5 and Figs. 7 and 8, Fig. 4 can be constructed and similar charts for other values of c can be obtained. A cross plot of such data for a constant value of Φ yields curves of TASI advantage similar to those of Fig. 3. The TASI advantage is $(n+1)/c$, inasmuch as there must be $n+1$ potential talkers in order to have n competing talkers.

In order to achieve a value of Φ less than 1%, it is necessary for y to be greater than unity, i.e.

$$y = \frac{c - np - \frac{1}{2}}{\sqrt{np(1-p)}} > 1$$

or

$$c > np + \sqrt{np} - \sqrt{np}\ (1 - \sqrt{1-p}) + 1/2$$

The last two terms are opposite in sign and each is small compared with the first two terms. This leads to the simple approximate relation that a practical TASI should be limited to the condition that $np + \sqrt{np} < c$.

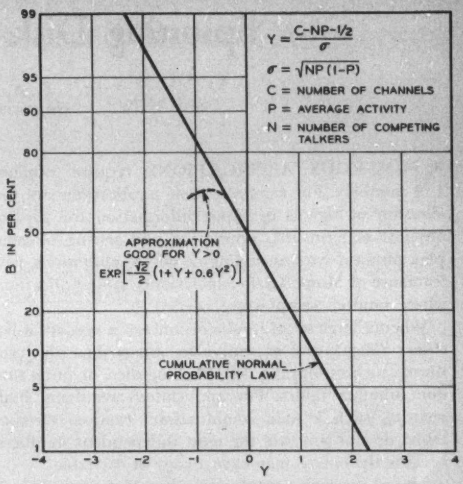

Fig. 7. Probability of freezeout $B_{(c,n,p)}$.

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Spinning Disk Random Selector

G. A. ROBERTS
ASSOCIATE MEMBER AIEE

NUMEROUS APPLICATIONS require random numbers. For example, some applications are the selection of signals or input information for psychophysical experiments, simulation and testing of complex physical systems, setting of safe combinations, performance of Monte Carlo experiments, and applications where random samples are needed.

When a large set of random numbers is needed, it becomes difficult and expensive to obtain these by techniques such as flipping coins, rolling dice, or using random number tables. For applications requiring high security, such as safe combinations, random number tables do not generate the most independent numbers, because the enemy may have a copy of the table.

Several electronic random selectors have been developed at the University of Michigan to provide large sets of random numbers for psychophysical experiments. One type, a manually operated spinning disk random selector with equally-likely selections is discussed in this article. Two spinning disk random selectors of this type are shown in Fig. 1.

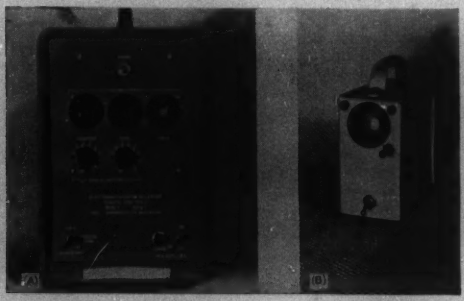

Fig. 1. Spinning disk random selectors. (A) Three decade with adjustable modulus. (B) Single decade, battery-powered.

The equally-likely spinning disk random selector can be separated into two functional parts: (1) a randomization source, and (2) an equally-likely random number generator.

One realization of an equally-likely random number generator consists of a cyclic pulse generator coupled by a switch to an electronic counter and a number readout unit. The switch is called a question switch.

Assume the counter to have a modulus of N (i.e., N unique, stable states), and the period between pulses to be t. Then one modulus cycle has a period T of Nt.

The counter must pass through each of its N states for every modulus cycle. Since the input pulses are equally spaced the counter will, on the average, be in each of its N states for the same period of time. If the counter is recurrently stopped in such a way that the stopping time is uniformly distributed over the modulus cycle, then the probability of a number being selected is equal to the fraction of time the counter stays on that number while the counter is being driven.

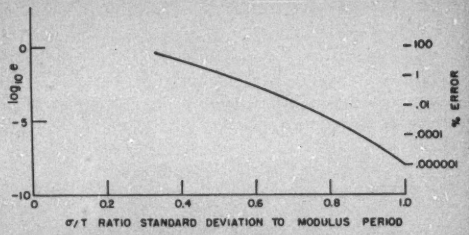

Fig. 2. Flatness of wrap-around probability density function, based on normal delay function. (e = error term, or relative peak-to-peak difference of the wrap-around probability density.)

If the selection time (the time the question switch is opened) is random, and the probability density of the selection time is uniformly distributed over T (the modulus period), then the numbers selected will be random and equally-likely. If successive selection times are independent, then successive numbers will be independent, with no patterning.

The mechanism for randomizing the number selection must operate the question switch at a random time and provide a uniform probability density function over the modulus period T.

Assume that the probability density distribution of the operation time of the question switch is approximated by a normal distribution in the infinite time domain. Then the spinning disk transforms this distribution in the infinite time domain into a different distribution in the finite time domain of the modulus period. By properly selecting the rate of operation of the counter relative to the standard deviation of the operation time of the question switch, it is possible to obtain an essentially uniform distribution of the operation time over the modulus period (Fig. 2).

For a manually operated random selector, a modulus period of 50 milliseconds will insure less than 1% variation in the probability density over the modulus period.

Digest of paper 58-534, recommended by the AIEE Electronic Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Great Lakes District Meeting, East Lansing, Mich., May 5-7, 1958. Published in AIEE *Communication and Electronics*, Nov. 1958, pp. 755-60.

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Induction Motors with Unbalanced Rotor Connections

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THE USEFULNESS of the method of symmetrical components in analyzing the case of an induction motor operating with an unbalanced rotor circuit has been limited by a lack of conclusive evidence as to what assumptions can be made in applying this method. The nature of assumptions useful to this analysis has been established through comparison of numerous experimental and calculated speed-torque curves. An accounting for the variation of both rotor and stator winding resistances with frequency has been found necessary for accurate prediction of these characteristics. It has been found that a linear approximation of the resistance-frequency variation in these windings is sufficiently accurate for calculations on small wound-rotor induction motors. Blocked rotor tests over a range of frequencies have shown the resistance-frequency variation to be essentially linear for this type of motor. It is to be expected that certain cases involving a configuration of conductors in the motor windings such as deep bars or untransposed parallel windings may involve a departure from the linear resistance-frequency variation. In these cases either tests or design calculations can be used to establish a more suitable approximation.

If one assumes that the stator circuit has balanced impedances and that it is energized from a balanced source of emf, it can be shown that unbalancing the rotor circuit results in unbalanced currents of slip frequency in the rotor and balanced component currents of line frequency and $(2s-1)$ times line frequency in the stator.

Let the rotor circuit have unbalanced impedances Z_a, Z_b, and Z_c in phases a, b, and c respectively. These impedances can be resolved into their symmetrical components Z'_0, Z'_1 and Z'_2, the subscripts 0, 1, and 2 referring to the corresponding sequence components of these impedances. Equations for the symmetrical components of rotor current are then:

$$I_{r1} = V_{oc1} \frac{s\,(Z'_o + Z_{m22})}{(Z'_o + Z_{m11})\,(Z'_o + Z_{m22}) - Z'_1 Z'_2} \qquad (1)$$

and

$$I_{r2} = V_{oc1} \frac{sZ'_1}{(Z'_o + Z_{m11})\,(Z'_o + Z_{m22}) - Z'_1 Z'_2} \qquad (2)$$

wherein:

sV_{oc1} is the open circuit rotor voltage per phase at the slip rings at slip frequency.

Z_{m11} is the impedance presented by the motor to positive sequence rotor current at slip frequency.

Z_{m22} is the impedance presented by the motor to negative sequence rotor current at slip frequency.

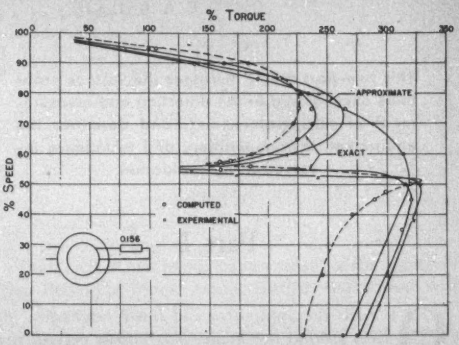

Fig. 1. Comparison of computed and experimental speed-torque characteristics with large rotor unbalance. Dotted curve corresponds to the computed characteristics assuming no variation in resistance with frequency.

The torques caused by these two sequence currents can be determined as a function of slip. These equations are general and apply to any kind of unbalance encountered in the rotor circuit. As a consequence of the nonreciprocal coupling between the positive- and negative-sequence networks, a single equivalent circuit cannot be derived for the general case. However, unbalance in one phase only or equal unbalances in two phases are symmetrical cases. For such cases, the foregoing equations degenerate into simpler ones which are reciprocal in nature and are, therefore, amenable to representation by equivalent circuits. Using 60-cycle stator resistance in equations 1 and 2, several speed-torque characteristics were computed and compared with corresponding experimental results. Correlation was poor, particularly in the high-torque and half-speed regions of operation. Fig. 1 shows the correlation of experimental and computed results to be well within ordinary requirements when the previously mentioned linear approximation of the winding resistance-frequency characteristics is used with respect to both rotor and stator windings. This figure also shows computed results obtained using constant, 60-cycle, stator resistance to be unsatisfactory in the high slip region. Use of averaged rotor resistance in the conventional, balanced equivalent circuit is shown by a third computed curve which illustrates the inapplicability of the averaged rotor resistance method in the high-torque half-speed region.

Digest of paper 58-1158, "Polyphase Induction Motors with Unbalanced Rotor Connections," recommended by the AIEE Rotating Machinery Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Pittsburgh, Pa., Oct. 26-31, 1958. Published in AIEE *Transactions*, vol. 77, 1958 (February 1959 section).

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Analysis and Evaluation of Noise in Household Refrigerators

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This two-part article discusses the various problems encountered in the detection and measurement of refrigerator noise, and describes the equipment, instrumentation, and techniques involved in its evaluation.

Part I

OF ALL the appliances and other mechanical devices around the home, it is almost certain that none is more apt to be subject to criticism from the standpoint of noise than the refrigerator. This is not because refrigerators are inordinately noisy, because when compared to other appliances and devices, it is easy to see that they are not. It very probably has something to do with the fact that the forerunner of the modern refrigerator, the ice box, made no noise at all in the ice-melting process, save for the water dripping into the pan beneath it, and even this was taken care of in many cases. In fact, it is known that people expect certain devices, such as vacuum cleaners, to be noisy, and are not pleased when they are made quiet because they erroneously sense a deficiency of power. Again, not so with the refrigerator. This is expected to be quiet just as the melting ice was in its predecessor. Another reason that people demand a quiet refrigerator quite probably stems from their automatic operation as opposed to the manual operation of vacuum cleaners and other devices.

EQUIPMENT

Environment or Test Room. For some evaluations, the test room might be a quiet corner of the laboratory with makeshift walls or heavy curtains to form a "listening booth." But this becomes quite inadequate the moment one attempts to examine noise on other than an aural basis. For investigation of noise contributions in most discrete frequency bands, and for establishing a history of reproducible data, a specially isolated room is a basic requirement. This room may be either anechoic (free field) or reverberant (diffuse), but one which has some of the characteristics of both is probably the most common. This compromise room is the so-called "padded cell" and is anechoic at very high frequencies and essentially reverberant at low frequencies.

Ideally, one each of the anechoic and diffuse field type rooms is required; the anechoic for absolute analysis and reproducibility, and the diffuse field for a controlled similarity to natural usage surroundings.

In almost all cases where the laboratory is in an industrial environment, a double-wall double-door room is necessary. The inner room is suspended on either springs or rubber to isolate all frequencies above about 4 cycles per second (cps).

The shape of the inner room can be a factor because of standing waves, particularly in the case of the padded-cell type structure. Generally speaking, a rectangular room is used and, to provide a good standing wave ratio, i.e., the most diffuse field, should be in a ratio of 3/4/5.[1] Of course, other room shapes can be developed which give optimism diffuse field, but this leads to very expensive construction.

The facilities as hereinafter described are those of the Evansville Division of Whirlpool Corporation. In these facilities there are at present two sound rooms, both of the padded-cell or semireverberant type. One (sound room A) is quite a satisfactory room and is shown in the photograph in Fig. 1 and the diagram of Fig. 2. This is of the double-walled construction described previously. Sound room B is shown in Figs. 3 and 4. This room is suspended on springs but does not have an enclosing wall around it. It is unsatisfactory in the high laboratory ambient noise environment because of wall-panel noise impingement and serves basically as a "listening room." It is interesting to note the effect of this room's extremely flexible mounting (1.6 cps) on visitors who encounter it without any prior explanation of the nature of its support.

A new double-wall room consisting of one padded cell and one reverberant test cell is under construction at the present time. This room is shown schematically in Fig. 5. It can be seen that the instrumentation is outside the suspended test chamber. This is possibly the best arrangement, because otherwise the instrument noise sometimes interferes with the test in progress, even when it is confined in a separate inside room as it is in Figs. 1 and 2. However, this has the disadvantage of removing the operator from the "feel" of the object on test.

Particular attention must be paid to the openings in the rooms. Each entry wall should have its own door, and both of these doors must have an effective door gasket seal. Any windows or view ports should be of

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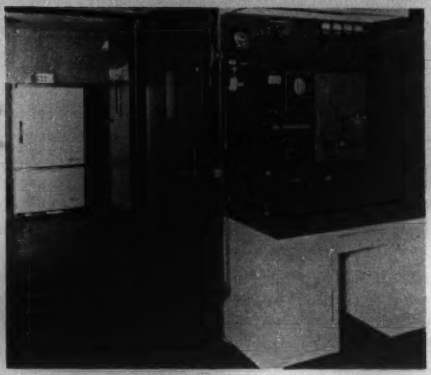


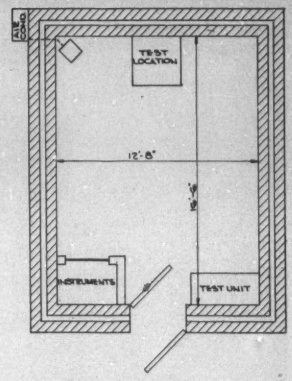


Fig. 1 (left). View of sound room A. Fig. 2 (right). Floor plan of sound room A.

double glazed construction with a significant dead-air space between the glass panes. All other openings for power, lighting, instrument cables, etc., should be well caulked. Any narrow aperture around these weak points in the structure will create an acoustic leak, particularly at high frequencies.

Temperature control of the test cell and instrument areas is desirable both from the standpoint of operator comfort and for minimizing the effect on the operating noise characteristics of the test object. One can well imagine the effect on operator comfort of having to remain for hours at a time in a completely isolated dead-air cell while temperature and humidity mount up and up. This temperature comfort problem can be dealt with in several ways. The least expensive method is to provide a direct-expansion fan-cooled refrigerated coil in the test room, with an external refrigeration system which is then pumped down and the fan turned off for complete absence of noise during test. This type system functions during non-test periods with the room doors open to provide ventilation. A system of this type has proved satisfactory in the facility shown in Figs. 1 and 2. Fig. 6 shows the other possibility which utilizes an air conditioned outer room with duct treatment to minimize noise carry-through, and with a baffled low-velocity conditioned-air system continually changing the air of the test cell. In the latter type, one pays the price penalty to provide continuous air temperature control with no resultant room acoustical impairment.

In the semireverberant room, the practice has been to endeavor to make the refrigerator perform noisewise in a manner similar to that encountered in a home. To this end, a solid floor is usually used under the refrigerator on test. A steel plate is sometimes desirable from a wear standpoint and provides a surface which is at least as much a reflective surface as any floor material that would be encountered. Generally, at least one wall is also hard surfaced to give the effect of the reflective plaster or tile kitchen wall, while the remainder of the interior surface of the test cell is treated with acoustic material to provide an environment with controlled absorption.

Inasmuch as numerous papers exist on the construction details of sound rooms, further elaboration will not be given here.

Instrumentation. The science of sound and, specifically, noise (which is often defined as objectionable or unwanted sound) is not a simple subject. Its complexity occurs because its study must involve not only physical factors, but psychological factors as well. This is because the human ear is not a simple measuring instrument, but rather one of nature's more complex structures. The ear not only functions as an extremely sensitive microphone, but also as a selective analyzer with the ability to extract pitch, loudness, and "quality" of particular frequencies in the presence of interfering background noise. The "quality," as referred to here, might be defined as human reaction expressed as pleasure, annoyance, or emotional feeling.

The task, then, of finding an instrument to make physical measurements of noise in some manner so that some of the human reactions to it can be classified would seem a formidable task, even if the factors mentioned previously were not interdependent, and also contingent upon the experience and environment of the listener.

In the final analysis, there are really only two *objective* properties of noise which are measurable. These are sound pressure level, expressed in decibels, and frequency, in cycles per second, and relate subjectively to loudness and pitch. Therefore, to attempt to instrumentate and achieve the measurable objective properties of noise we must, in various degrees of elaboration, provide a transducer to pick up airborne or structure-borne vibrations. This is because noise has its source in vibration, i.e., a microphone or vibration pickup; an amplifier to transform the output of the transducer into a useful signal level; a means of controlling the signal both as to intensity and choice of frequency response, such as an attenuator and weighting networks; a means to segregate out certain specific frequency ranges for detailed analysis; and a means of indicating or recording the output signal.

It was not too long ago that the measurement of

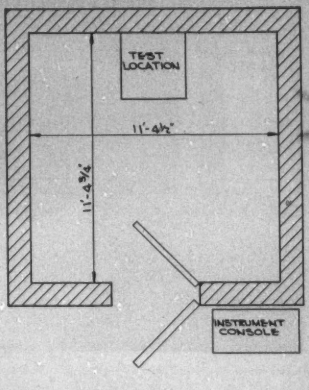


Fig. 3 (left). View of sound room B. Fig. 4 (right). Floor plan of sound room B.

sound pressures was a complex task involving the use of classical physics techniques. Even the first commercial measuring instruments were complex and bulky enough to fill several sizable suitcases. Then, about 18 years ago, a lightweight commercial instrument was developed which is basically that in common usage today except for the more compact and stable circuitry which seemingly always results from expanded usage and the demands of the users. The basic sound-measuring instrument, and the one which incorporates in a sense all of the foregoing criteria is the sound level meter (SLM). The General Radio Company *1551A* SLM used consists of a microphone, amplifier, attenuator, weighting network, and an indicating meter. Its input circuit is adapted to receiving auxiliary pickups and its output will feed a great variety of auxiliary analytical and recording apparatus.

Commercial sound level meters are generally comparable, since all are made to meet American Standard (ASA) Z24.3 requirements. Inherent to their required usage are stability, low internal noise, distortion-free signal, high input impedance, good overload characteristics, and freedom from response to vibration. Most sound level meters in their portable form are powered by batteries, but provision is generally made for laboratory a-c operation. The frequency weighting networks were originally thought to make the SLM a loudness meter, but it has been since found that loudness cannot be so easily determined. However, the weighting networks do enable a standardization of design and make possible a very rough estimation of the frequency characteristic of the noise.[2] The *A*, *B*, and *C* weighting networks are standard, with the *A* network approximating the ear response from about 35 to 55 db, the *B* network from 55 to 85 db, and the *C* network above 85 db. The *A* and *B* networks give sound level and the *C*, or flat, network gives sound pressure level.

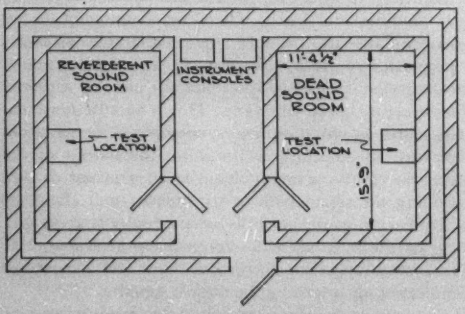


Fig. 5. Floor plans of sound rooms under construction.

The microphone imposes certain limitations on the sound-measuring system. No one microphone can meet all the desirable characteristics of wide frequency range; flat response; accuracy; sensitivity; ruggedness; and temperature, pressure, and humidity performance—and do so at reasonable cost. The best compromise is chosen by the SLM manufacturer, and then it is left to the ultimate user to pick the microphone or microphones best adapted to his measurement task. At least six types of microphones lend themselves to use with the SLM, the two most commonly applied being the Rochelle salt crystal type and the moving-coil dynamic type.

Test methods described here have utilized both of these types and the condenser microphone for certain test procedures. The dynamic microphone has been found to be most satisfactory, because it is relatively unaffected by temperature, long cables, and continued usage. Its primary disadvantage of hum pickup in strong magnetic fields is minimized by picking microphone test locations far enough removed from such sources. As has been previously implied, it is unrealistic to assume that a single meter reading such as the sound level *A* network can give an adequate expression of the effect of noise on the human ear. To evaluate this effect, one must include an analysis of the frequency characteristics of the noise. Then, and only then, can valid, meaningful expression be made of noises of different character. And too, present-day knowledge allows correlation with loudness as heard by the ear.

To perform the breakdown of the noise into its fre-

quency characteristics, electric filters, which effectively reduce the response of the signal above and below a desired band of frequencies, are used. Two general classes of these filters are employed, and are called wide-band analyzers such as the full, half, and one-third octave analyzers; and the narrow-band or discrete-frequency analyzer. Again, there are a number of options to choose from, but it has been found that the constant-percentage bandwidth analyzers, one each of the full-octave and discrete-frequency types, perform almost all the desired types of analytical assignments. Of course, there are cases where an instantaneous analysis by visual presentation can be desired, and that can be met by use of a Radio Products, Inc., panoramic sonic analyzer. This statement is particularly adapted to the study of variations in noise characteristics and the study of "cause and effect" on a frequency vs intensity basis.

A more precise visual record of the spectrum of the output of the SLM is that obtained by a sound analyzer used in conjunction with a graphic level recorder. Such a recorder must be both accurate and stable, with variable speed desirable. When used with an analyzer, the motion of the chart must be synchronized with the frequency of the pass band of the analyzer either by an electrical or mechanical linkage. Use of such an instrument eliminates much of the labor of data taking and at the same time yields a permanent record for reports and further detailed analysis.

Another recording instrument plays an important part in noise analysis, this time on the input end of the SLM or analyzer. This is the magnetic-tape recorder, one type of which can be seen in Fig. 3. Its value is threefold: it preserves the noise for future analysis when time is pressing or measurements are made away from the laboratory; it provides noise samples for comparison with reference sources or other samples for statistical indices; and it provides a record for reference when an aural evaluation is to be made on a comparative basis. It follows that to achieve this, the recorder used must be of high quality with flat frequency response, low hum, low internal noise, low nonlinear distortion, wide dynamic range, constant-speed drive, and top-notch mechanical construction.

All of the instruments discussed in the foregoing are compatible, and can be linked together by a calibration means so that a consistent and logical interpretation of results is obtained. The method which takes the microphone into the calibration system is most desirable, hence a need is implied for a stable audio-frequency source, a voltage-measurement means, and a transducer to couple the measured audio signal to the microphone. Such a system enables repetitive results to be obtained within about ± 1 db over extended test usage. The system used in this instance is the General Radio *1552B* calibrator fed by 2 volts at 400 cycles from a beat frequency oscillator, coupled to the SLM microphone, and with its output variously coupled to the analyzers and recorders which may be used during any particular test.

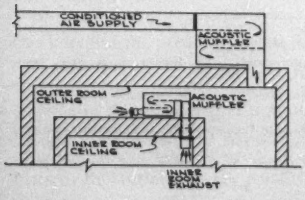


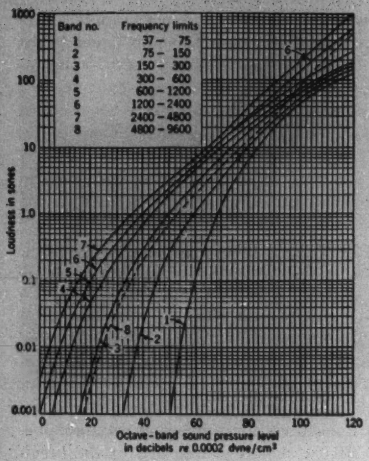
Fig. 6. Diagram of conditioned-air system for sound rooms of Fig. 5.

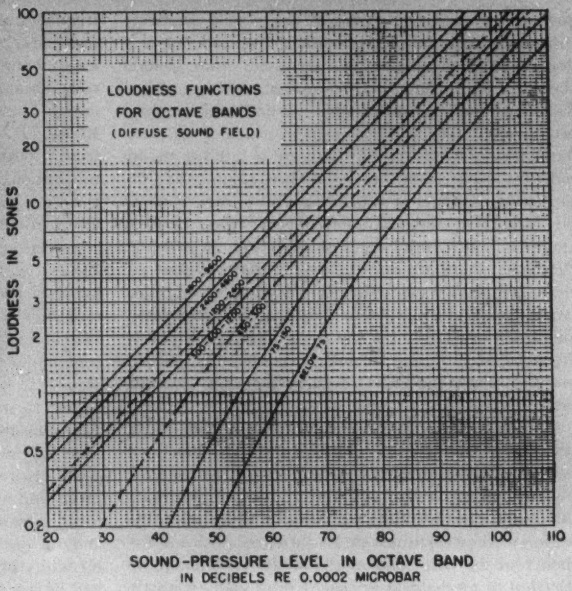
Special apparatus which finds various degrees of usefulness in the laboratory includes the impact noise analyzer for analysis of impulsive noises; the oscilloscope for wave analysis and general visual inspection of planned phenomena; the Polaroid camera for photographic record of oscillographic portrayals; the beat frequency oscillator for use as a variable frequency source as well as supplying a calibrating 400-cps signal; pressure transducers for converting pressure phenomena into electric signals to feed any of the previously discussed instruments; vibration pickups of the probe and minimum-mass type for analysis of displacement, velocity, and acceleration of vibrating structures; and various other instruments. This is in the area of ingenuity of the test operator, and further description will be left to the imagination of the reader.

EXPRESSION OF NOISE TEST RESULTS

FOR MOST PEOPLE, when "noise measurement" is mentioned, their immediate thought is "decibels." This has become almost a universal word in this regard. Actually, the use of decibels as a rating scale for the loudness of a noise has a serious drawback, namely that decibel readings have little relation to the "loudness" of a noise as "heard" by the ear. This is because, as has been previously stated, the ear's response is not flat with respect to frequency or, in other words, it tends to evaluate different frequencies differently and not on the basis of sound pressure or power levels which, in this case, decibels represent. Although this is partly taken into account by weighting networks on the sound-level meters, it is not nearly accurate enough to make the resultant db readings represent a rank order of loudness.

Nevertheless, the db rating scale can be used to rate such things as the noise from a number of similar machines, each having about the same frequency make-up. This is not completely accurate, but results have shown such readings are, for the most part, at least indicative of how loud the noise being studied is. This is definitely inferior, however, to a rating system based on sones, which does not presuppose a similar frequency distribution, and which, therefore, is more universally applicable. To obtain the sone value for a sound, it is first necessary, when measuring low-level noise, to feed the flat-network db signal from an SLM into an octave band analyzer, which gives a db reading for each of a series of frequency bands. From a loudness vs octave band sound-level chart can be obtained the value from each frequency band, and then, by apply-





Figs. 7 (above) and 8 (right). Charts used for converting from octave-band levels in decibels to loudness in sones.

ing a simple formula, the over-all loudness in sones for the particular noise in question can be obtained.

There are two methods of performing the aforementioned computation of sones, each based on its own chart and formula. The one which has been in use for a number of years and is still a useful method is that which utilizes the chart of Fig. 7, which is based on work done by Beranek and Peterson.[2] After the sone value is determined for each band, the total number of sones is obtained by simply adding together the loudness for all bands, or

$$S_t = S_1 + S_2 + \ldots + S_8 = \Sigma S$$

where

S_t = over-all loudness
$S_1, S_2 \ldots$ = loudness in each band
ΣS = sum of all loudness for all bands

The other method has been rapidly gaining favor in the literature and in practice and is from the work of Dr. S. S. Stevens of the Psycho-Acoustic Laboratory at Harvard University. This consists of using the chart shown in Fig. 8[4] and then applying the equation

$$S_t = S_m + F\,(\Sigma S - S_m)$$

where

S_t, ΣS are as before and
S_m = the loudness of the loudest band
F = a factor depending on measurement conditions (0.3 for octave band measurements)

This second method is now being recognized as giving more reliable and consistent results than the first method, and will very probably be the method used in the future in work such as that described in this article.

It can easily be seen that it is possible by either method to have a sound with a lower decibel reading than another be the louder of the two. This is very often true when one sound has strong high-frequency components as compared to another which has strong low-frequency components. The one with the predominant high frequency will generally be the louder, even though the db rating may be equal or even reversed.

(This article will be concluded in the July 1959 issue of *Electrical Engineering*.)

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The Turbonator: Design and Development

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J. W. HARRISON

AIRCRAFT electric system generators have been changing from the wide-speed-range, d-c machines of 15 years ago to the constant-frequency, 400-cps a-c systems widely used today. These constant-frequency generators require a fixed-speed shaft. This is sometimes provided by supplying engine shaft power through variable gear ratio devices. In other cases, generators are driven by fixed air turbines operating on air bled from the engine compressors. Design problems in these systems center on the reduction of weight and compatibility with the environmental conditions presented by high performance aircraft. It was in an effort to meet these problems that the Turbonator, an integrated turbine–generator package, was conceived and developed.

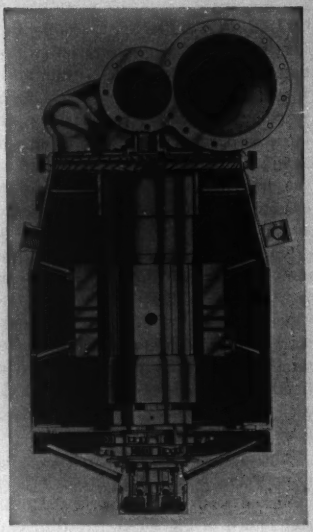

Fig. 1. Cutaway view of experimental Turbonator.

Design studies made on the geared turbine system and a direct-drive turbine system established that there was a substantial weight advantage to the direct-driven system using a common shaft for both turbine and generator and only two main bearings. This arrangement gave a system weight lower than either the hydraulic or air turbine constant-speed drive systems or the integrated hydraulic constant-speed drives. Analysis of current and proposed jet engine designs and electric load requirements showed that 24,000 rpm would be the desirable turbine speed.

The concept of an integrated package of air turbine and generator leads naturally to the consideration of cooling the generator and bearings with the air that has passed through the turbine. When a turbine is delivering power, its temperature drop is proportional to available energy in the air and turbine efficiency, while air flow is proportional to the load. As electric load on the generator is increased, air flow through the turbine must increase and the temperature of the air exhausted from the turbine decreases. Both effects lead to increased cooling capacity available for the generator. This extra cooling is required by the generator as its load increases, but in the typical Turbonator, the extra cooling more than compensates for the additional losses, and winding temperatures actually decrease slightly as load increases. Thus, the Turbonator is unique in that additional cooling required by the generator is provided automatically by the turbine's air flow characteristics.

In order to evaluate the Turbonator concept and to check by test the predicted characteristics of the 24,000-rpm generator, a sample unit was built and tested. Fig. 1 pictures the physical location of the various components in the experimental unit. Multiple ducting at the top of the figure accommodates the partial-arc air supply which is used to match the turbine characteristics to the various energy conditions of the inlet air supply. Immediately below the inlet is the frangible turbine wheel with buckets designed to fail above maximum overspeed, but below the burst speed of any other rotor elements. Below the wheel is a 4-inch hydrostatic air bearing and next the 2-pole round-rotor generator. Below it is a small 1,600-cps permanent-magnet generator used for speed control and build-up purposes, a slip-ring assembly, and an oil-lubricated ball-bearing capsule.

Extensive tests at both sea level and altitude on the complete Turbonator showed it to be entirely satisfactory. Both cooling performance and air flow rates on the over-all unit substantiated predicted values. The 24,000-rpm operating speed and 30,000-rpm overspeed presented no problems because the design permitted the use of factors of safety identical to those used for 6,000- and 8,000-rpm aircraft machines. Both the oil and air bearings worked well.

Evaluation of test results has convinced the authors that the Turbonator concept is a sound one and that it offers an exceptionally sound answer to generating problems on aircraft of the future.

Digest of paper 58-791, recommended by the AIEE Air Transportation Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting and Air Transportation Conference, Buffalo, N. Y., June 22-27, 1958. Published in AIEE *Applications and Industry*, Nov. 1958, pp. 316-22.

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Equations for Induction Motor Torque and Power

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THE EQUATIONS available for determining the developed torque and power of induction motors deserve critical review. Accurate and convenient equations are necessary to encourage designers to avoid approximate short-cut calculations. However, an even more important result of having improved equations available is that this can provide a first step toward the development of synthesis procedures[1] which would establish motor dimensions by direct calculation from specifications.

Improved equations are made possible by use of a circuit theorem which establishes equivalence between right- and left-hand L networks. It has been shown[2] that the equivalence of two circuits usually does not extend further than the equality between corresponding terminal quantities. For the equivalent right- and left-hand L networks, however, there exists a simple complex number ratio between the phasor currents of the load impedances.

The relationships determined for right- and left-hand L networks permit the circuit of Fig. 1 (B) to be established from the well-accepted exact equivalent circuit shown in Fig. 1 (A). A torque equation can be derived by using the value of load current as determined from the new circuit shown in Fig. 1 (B) and then converting this to the value flowing through the load resistance of the exact circuit. The conversion factor is called $\overline{M}$. It can be shown that

$$\overline{M} = 1 + \overline{Z}_1/Z_0 = M_x + j\,M_y \tag{1}$$

The accurate torque equation derived[1] in this way is:

$$T_m = \frac{7.04\ m s V^2 R_2}{n_s\left[(sR_1 + M_xR_2 - sM_yX_2)^2 + (sX_1 + sM_xX_2 + M_yR_2)^2\right]} \tag{2}$$

where

m = number of phases
n_s = synchronous speed in rpm
s = slip
T = developed torque in pound-feet

and all other quantities are shown on the per-phase equivalent circuit of Fig. I (A).

From equation 2, the slip at which maximum developed torque occurs can be found with complete theoretical accuracy to be

$$s_{mt} = \frac{MR_2}{\sqrt{R_1^2 + X_1^2 + M^2X_2^2 - 2M_yR_1X_2 + 2M_xX_1X_2}} \tag{3}$$

It has been found that these equations can be simplified with surprisingly little loss of accuracy by neglecting M_y and defining

$$M_x \approx 1 + X_1/X_0 \tag{4}$$

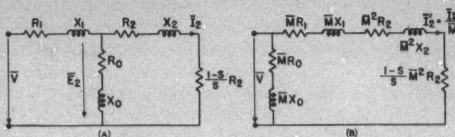

Fig. 1. Equivalent circuits for induction motor.

This approximation permits the torque to be written

$$T \approx \frac{7.04 m s V^2 R_2}{n_s\left[(sR_1 + M_xR_2)^2 + s^2\,(X_1 + M_xX_2)^2\right]} \tag{5}$$

Slip at which maximum developed torque occurs is

$$s_{mt} \approx \frac{M_xR_2}{\sqrt{R_1^2 + (X_1 + M_xX_2)^2}} \tag{6}$$

And the maximum developed torque is

$$T_M \approx \frac{7.04 m V^2}{2n_s\,M_x\left[R_1 + \sqrt{R_1^2 + (X_1 + M_xX_2)^2}\right]} \tag{7}$$

The relative magnitudes of the impedances in the induction motor equivalent circuit indicate that the error caused by the approximations made to simplify the equations should be slight. The accuracy of equations 4 to 7 was tested using data for a 15-hp motor[3]; s_m differed from the value obtained by repeated analysis of the exact equivalent circuit by less than 0.1 per cent; and T_M was in error by only 0.2 per cent, compared to 5.6 per cent by the usual equation.

Using the procedure suggested in problem 18.32 of reference 2, similar improvements can be made in the equations for maximum developed power.

Since these equations enjoy such accuracy and simplicity, it seems that they should be put to use in induction motor design offices and should find their way into machinery textbooks of the future.

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The Bode Diagram

An Approach to Regulating-System Stability Fundamentals

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The difference between stable and unstable systems is demonstrated logically from the standpoint of the frequency-response diagram, often called a Bode diagram. In addition to providing a means of understanding fundamentals of regulating systems, the Bode diagram is a useful design tool.

REGULATORS are now widely used in various fields of industrial control, including processing line control, materials handling control, and machine tool control. Tension regulators, speed regulators, voltage regulators, and position regulators represent some of the most common regulator applications. The list of available types of regulators includes electronic, rotating, magnetic amplifier, and transistor regulators, as well as the older electromechanical types such as the carbon pile and rocking contact regulators.

With the use of regulators have come problems of instability, or hunting, which have been solved in various ways.

Although much has been written about the use of computers to predict and correct stability problems, the basic cause of hunting is still a mystery to many engineers, especially to those who do not wish to become deeply involved in differential equations.

The purpose of this article is to demonstrate logically, if not rigorously, what it is that makes the difference between stable and unstable systems. A typical regulating system will be investigated from the standpoint of its frequency-response diagram, which is often called a Bode diagram because of the outstanding work done in this field by H. W. Bode.[1]

FUNDAMENTAL REGULATING-SYSTEM RELATIONSHIPS

IN FIG. 1 are shown the basic elements of a regulating system. The differencing element is some means of measuring the difference between the reference R and the feedback B so that

$$E = R - B \tag{1}$$

E then is the error, or the difference between the reference and the feedback.

The error is applied to a control system having a gain G, where the gain is the ratio of the control system output to the control system input. If C is the control system output, or controlled variable, then

$$C = EG \tag{2}$$

The feedback B is the equal to the controlled variable C multiplied by the feedback circuit gain H.

$$B = CH \tag{3}$$

In many regulating systems, H is unity, so in those particular cases, B is equal to C.

The term open loop gain is often used, and this term refers to the ratio B/E. It is equal to GH because

$$\text{open loop gain} = \frac{B}{E} = \frac{C}{E} \times \frac{B}{C} \tag{4}$$

and

$$\frac{B}{E} = G \times H \tag{5}$$

In a regulating system, the feedback is often called negative feedback. The difference between positive and negative feedback is a very important one, and can be demonstrated by reference to Fig. 2.

Fig. 2 is similar to Fig. 1, with the loop opened between the differencing element and the control system. For the purposes of this discussion, it will be helpful to consider the relationship of E_1 to E_2, with $R = 0$.

For this system:

$$E_1 = R - B = -B \text{ (for } R = 0) \tag{6}$$

$$B = E_1 GH \tag{7}$$

$$E_1 = -B = -E_1 GH \tag{8}$$

Thus, it can be seen that the polarity of E_1 is opposite to that of E_2. A positive change of E_2 will then produce a negative change of E_1. The feedback is said to be negative, or degenerative, because the change in E_1 is opposite in direction to the change in E_2 which caused it. This feature is characteristic of any regulating system.

The regulating system of Fig. 2 could be considered as a feedback amplifier, in which E_2 is the input to the amplifier, and E_1 is the portion of the output which is fed back to the input.

If the feedback were positive, that is, if

$$E_1 = E_2 GH \tag{9}$$

the system would be an amplifier with regenerative feedback. A positive change of E_2 would then produce a positive change of E_1.

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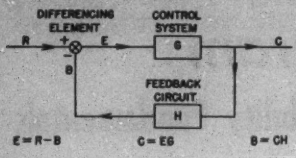
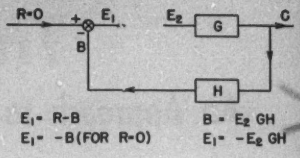


Fig. 1 (*left*). Basic elements of a regulating system. (*R*=reference; *B*=feedback; *E*=error; *C*=controlled variable; *G*=control system gain; *H*=feedback circuit gain.) Fig. 2 (*right*). Regulated system with loop opened and with *R*=0.



A regenerative feedback amplifier, under certain conditions, may become an oscillator. In fact, a feedback oscillator is one particular type of regenerative feedback amplifier.[2]

Occasionally, what is intended to be a regulating system ends up being an oscillator. The criteria for determining whether a system is a stable system (feedback amplifier) or an unstable system (feedback oscillator) are extensively treated in the literature.[3,4,5] A somewhat oversimplified statement of the basic criterion is that a system will be unstable if a positive feedback condition exists while the open-loop gain is greater than unity. This statement means that a regenerative feedback amplifier becomes unstable if the portion of the output which is fed back is greater than the input. This simplified statement is not complete, but a more exact criterion will be given later in this article.

EXAMPLE OF TYPICAL REGULATING SYSTEM

In Fig. 3 is shown a simple d-c generator voltage-regulating system, which has all the basic elements of a regulating system, as shown in Fig. 1. Also, as will be shown, this regulating system has all the necessary requirements for an oscillator.

In this system, the reference, the feedback, the error, and the controlled variable are all voltages. In other systems, some of these items might be speeds, currents, ampere-turns, or other units. Also, in this particular system, the feedback circuit gain is unity, so that the feedback is equal to the controlled variable.

The control system consists of three elements: an amplifier, an exciter, and a generator.

It is convenient to represent the regulating system as a block diagram, as shown in Fig. 4. The three elements of the control system have gains G_1, G_2, and G_3, so that the total gain G of the control system is the product of G_1, G_2, and G_3:

$$G = G_1 G_2 G_3 \tag{10}$$

This particular amplifier produces 60 volts output with an input of 24 volts. Assuming that the relationship is linear, the steady-state gain is 60/24 or 2.5. The steady-state gain will be referred to as A, and the difference between this term and the general term gain, or G, will be discussed later. Then

$$A_1 = \frac{60}{24} = 2.5 \tag{11}$$

The exciter produces 240 volts at the armature with 60 volts applied to the field. Again, assuming a linear relationship,

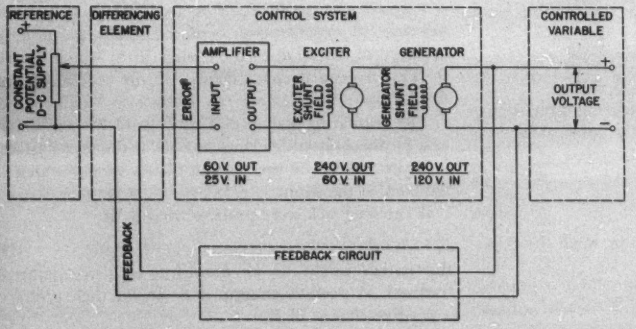
$$A_2 = \frac{240}{60} = 4 \tag{12}$$

The generator produces 240 volts at the armature with 120 volts applied to the field. In this case, assuming linearity,

$$A_3 = \frac{240}{120} = 2 \tag{13}$$

Then A, the steady-state gain of the control system, is

$$A = A_1 A_2 A_3 = 2.5 \times 4 \times 2 = 20 \tag{14}$$



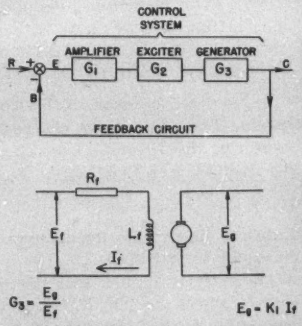


Fig. 3 (*left*). D-c generator voltage regulator circuit. Fig. 4 (*upper right*). Block diagram, voltage regulator circuit. Fig. 5 (*lower right*). D-c generator circuit. (E_f=field voltage; I_f=field current; E_g=armature voltage; R_f, L_f=field circuit resistance and inductance.)

The steady-state gain is useful in calculating the steady-state voltages in the system. Under steady-state conditions, G is equal to A. For the example under consideration:

$$G = A = 20 \text{ (for steady state)} \tag{15}$$

If it is desired that the generator voltage C be 240 volts,

$$E = \frac{C}{G} = \frac{240}{20} = 12 \text{ volts} \tag{16}$$

Also, from equation 1

$$R = E + B \tag{17}$$

But

$$B = C = 240 \tag{18}$$

Then

$$R = 12 + 240 = 252 \text{ volts} \tag{19}$$

Therefore, to get 240 volts at C, a reference voltage of 252 volts must be applied at R.

TRANSFER FUNCTIONS

THE STEADY-STATE GAIN, however, does not tell the complete story. It will be helpful to look more closely at G_3, the gain of the d-c generator.

In Fig. 5, R_f is the field circuit resistance, L_f is the field circuit inductance, E_g is the armature voltage and E_f is the field voltage. G_3, the gain of the generator, is then E_g/E_f.

If the generator speed is constant and if the saturation curve is a straight line, the armature voltage is proportional to the field current:

$$E_g = K_1 I_f \tag{20}$$

where K_1 is a constant.

If there were no such thing as alternating current, it would be permissible to say

$$I_f = \frac{E_f}{R_f} \tag{21}$$

Then

$$E_g = K_1 \frac{E_f}{R_f} \tag{22}$$

and

$$G_3 = \frac{E_g}{E_f} = \frac{K_1}{R_f} \quad \text{(for d-c only)} \tag{23}$$

In the foregoing example, K_1/R_f is equal to 2, the steady-state gain.

$$A_3 = \frac{K_1}{R_f} = 2 \tag{24}$$

However, anyone who has had experience with d-c regulating systems must realize that it is possible to get alternating currents and voltages in the system. This undesirable condition is commonly called hunting. A hunting regulating system is, in effect, an oscillator. An oscillator will produce alternating currents and voltages with only d-c voltages applied to it. Denying the existence of alternating currents and voltages will not prevent oscillation.

Inasmuch as it is possible to get alternating currents and voltages in the system, equation 21 does not hold true for the general case. Instead, it is necessary to write the a-c circuit equation

$$I_f = \frac{E_f}{R_f + j\omega L_f} \tag{25}$$

where ω is the frequency in radians per second or

$$I_f = \frac{E_f}{R_f} \frac{1}{1 + j\omega \frac{L_f}{R_f}} \tag{26}$$

and

$$E_g = K_1 \frac{E_f}{R_f} \frac{1}{1 + j\omega \frac{L_f}{R_f}} \tag{27}$$

Then

$$G_3 = \frac{E_g}{E_f} = \frac{K_1}{R_f} \frac{1}{1 + j\omega T_3} \tag{28}$$

where

$$T_3 = \frac{L_f}{R_f} \tag{29}$$

the time constant of the field circuit, or

$$G_3 = A_3 \frac{1}{1 + j\omega T_3} \tag{30}$$

Thus, the gain G_3 is equal to the product of the steady-state gain A_3 and a factor $1/(1 + j\omega T_3)$, which depends on the frequency and on the time constant of the field circuit.

The gain G, when expressed as a function of $j\omega$ is commonly called the transfer function.

The exciter transfer function will, of course, be of the same form as the generator transfer function

$$G_2 = A_2 \frac{1}{1 + j\omega T_2} \tag{31}$$

where T_2 is the exciter field time constant.

Assuming that the amplifier contains only a single time constant, the amplifier transfer function will be of the same form as the generator and exciter transfer functions

$$G_1 = A_1 \frac{1}{1 + j\omega T_1} \tag{32}$$

where T_1 is the amplifier time constant.

In this particular example, the transfer functions of

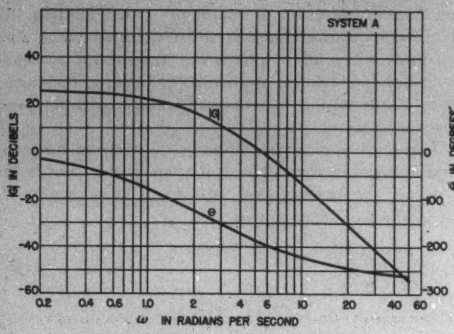


Fig. 6. Bode diagram for amplifier of system A.

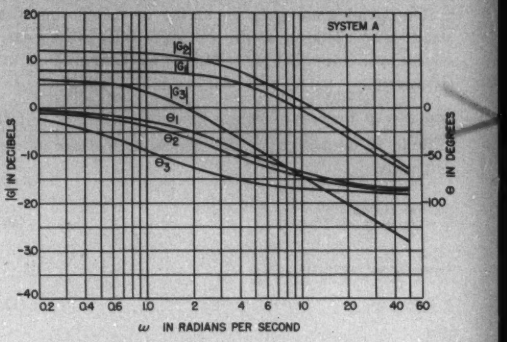


Fig. 7. Bode diagram for elements of system A.

the elements of the control system are all of the same form, namely

$$G = A\,\frac{1}{1+j\omega T} \tag{33}$$

Some regulating systems will include elements whose transfer functions are of a different form.

The transfer function G is a complex quantity similar to the impedance or admittance of an a-c circuit. At any given value of ω, G has a magnitude $|G|$ and a phase angle or phase shift θ. When G is of the form shown in equation 33,

$$|G| = \frac{A}{\sqrt{1+(\omega T)^2}} \tag{34}$$

and

$$\theta = -\tan^{-1}\omega T \tag{35}$$

PLOTTING OF BODE DIAGRAMS

It is very helpful to plot both $|G|$ and θ as a function of ω. Such a plot is the frequency response diagram, or Bode diagram, mentioned earlier. In order to simplify the plotting, semilogarithmic paper is usually used, and $|G|$ is plotted in decibels.

For a particular regulating system, which will be called system A, it will be assumed that the time constants are as shown in Table I.

For system A, the transfer function of the amplifier is

$$G_1 = \frac{A_1}{1+j\omega T_1} = \frac{2.5}{1+j\omega\,0.25} \tag{36}$$

$$|G_1| = \frac{2.5}{\sqrt{1+(\omega\,0.25)^2}} \tag{37}$$

$$\theta_1 = -\tan^{-1}\omega\,0.25 \tag{38}$$

It is now possible to calculate $|G_1|$ and θ_1 for the various values of ω. Calculated values of $|G_1|$ and θ_1 are listed in Table II and plotted in Fig. 6. The numerical value of $|G_1|$ is converted to decibels by taking the logarithm to the base 10 of the number and multiplying it by 20.

$|G_2|$, θ_2, $|G_3|$, and θ_3 can also be calculated for various value of ω. These calculations have been made, and Fig. 7 shows the Bode diagram for each element of the control system. To obtain the Bode diagram for the complete control system, it is merely necessary to add the values (in decibels) of $|G_1|$, $|G_2|$, and $|G_3|$ to get $|G|$. Similarly, θ is obtained by adding θ_1, θ_2, and θ_3.

Fig. 8 shows the Bode diagram for G, the transfer function of the complete control system. The Bode diagram for GH, the open-loop gain or transfer function, is what indicates whether the system will be a regulating system or an oscillator. In this particular system, however, H is unity, so that the open-loop transfer function is the same as G. Referring to Fig. 8, it will be noted that $\omega = 4.5$, θ is -180 degrees, and $|G|$ is 4 db.

As was discussed previously, the system contains negative feedback when considered from a steady-state

Table I. Constants of System A

	Steady-State Gain, A	Time Constant, T
Amplifier	2.5	0.25
Exciter	4.0	0.33
Generator	2.0	1.00

Table II. Values of Magnitude and Phase Shift for Transfer Function of Amplifier of System A*

ω, radians per second	$\lvert G_1\rvert$, numerical	$\lvert G_1\rvert$, db	θ_1, degrees
0.2	2.5	7.96	— 2.9
0.3	2.5	7.96	— 4.3
0.5	2.48	7.92	— 7.1
0.7	2.46	7.84	— 9.9
1.0	2.42	7.72	—14.0
2	2.24	7.02	—26.6
3	2.00	6.04	—36.9
5	1.56	3.90	—51.4
7	1.24	1.88	—60.3
10	0.93	— 0.64	—68.2
20	0.49	— 6.18	—78.7
30	0.33	— 9.62	—82.4
50	0.20	—13.96	—85.4

*$A_1 = 2.5$, $T_1 = 0.25$

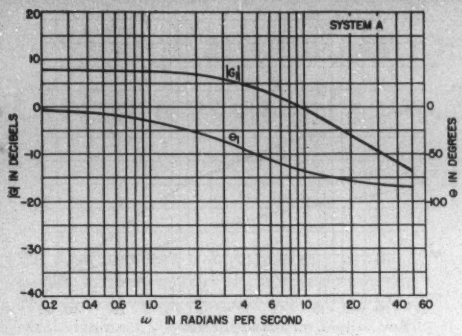


Fig. 8. Bode diagram for system A.

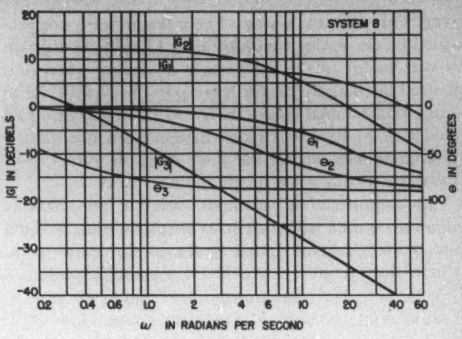


Fig. 9. Bode diagram for elements of system B.

viewpoint. However, the only different between positive and negative feedback is 180 degrees of phase shift. Therefore, at $\omega = 4.5$ the phase shift is -180 degrees and the feedback is positive. Since the gain is greater than 0 db or greater than unity, the system will oscillate, according to the simplified criterion given earlier.

A more exact method of determining stability is to note the phase shift at the value of ω for which $|G|$ is zero decibels. If this phase shift is called ϕ, then $(180 + \phi)$ is called the phase margin. The more exact criterion is that a system with a positive phase margin is stable, whereas a system with a negative phase margin is unstable.[6] In system A, under consideration, $|G|$ reaches 0 db at $\omega = 5.5$, and at this value, θ is -192 degrees. The phase margin is 180—192, or -12 degrees, and the system is unstable.

It will be interesting to consider a system similar to the aforementioned system, but with different time constants. Let it be assumed that for the new system, which will be called system B, the time constants are as shown in Table III.

Fig. 9 shows the Bode diagram for each of the three elements, and Fig. 10 shows the Bode diagram for the complete control system. In this system $|G|$ is 0 db at $\omega = 3.3$, and at this value of ω the phase shift θ is only -130 degrees. The phase margin is then 180—130, or 50 degrees. System B, therefore, is stable. It is generally considered desirable that the phase margin be 40 degrees or more to insure a stable system without an excessive amount of overshoot.

System A could have been made stable by the addition of one or more internal feedback circuits, sometimes called antihunt circuits. These circuits modify the system transfer function in such a way as to provide a positive phase margin. It is possible to calculate values of $|G|$ and θ for a system which includes internal feedback loops,[7] and once the Bode diagram for the open-loop transfer function is plotted, the criterion for determining stability is the same as described before: the phase margin must be positive and preferably should be 40 degrees or more.

Table III. Constants of System B

	Steady-State Gain, A	Time Constant, T
Amplifier	2.5	0.05
Exciter	4.0	0.20
Generator	2.0	5.00

LIMITATIONS OF BODE DIAGRAMS

EXPERIENCE SHOWS that the Bode diagram is a very useful tool in regulating system design. There are, however, several limitations to the use of the Bode diagram.

The more complex systems, with several internal feedback loops, are cumbersome to handle and require considerable time to get accurate results. There are approximate methods which save a great deal of time and are very useful for preliminary work.

It is very difficult to take into account the effect of nonlinearities when the Bode diagram is used. Also, the transfer functions of some regulating system elements are functions of two variables, and these are difficult to handle with the Bode diagram. An example of this type of transfer function is a d-c motor with shunt field control.

In addition to stability, an important characteristic of a regulating system is its speed of response. Determination of the speed of response accurately from the Bode diagram is also a difficult matter, although methods for doing this have been developed.

For these reasons, the electronic analog computer has become very important in the investigation of regulating system performance. With the analog computer, nonlinearities can be handled easily. Functions of two variables represent no serious problem. The speed of response is easily obtained. Finally, the time required to get accurate results is greatly reduced.

Even with the use of the analog computer, the Bode diagram remains an important tool for investigation of regulating systems. It provides a valuable picture of why a particular system will be stable or unstable, and indicates what type of stabilizing circuit is required to

correct an unstable system. These features are not provided by the analog computer itself. The Bode diagram is very useful in the early stages of design, when it is desired to compare two or more possible systems. Realizing that the final system design will be checked on an analog computer, the system designer can use the approximate methods on the Bode diagram, rather than the exact methods, for his preliminary work.

The approximate methods save a considerable amount of time over the exact methods, thus making the Bode diagram practical for preliminary work, where the pictures it provides are most helpful.

CONCLUSION

THE DIFFERENCE between a stable and an unstable system has been explained by means of the Bode diagram. Use of differential equations has been avoided in the belief that a more general understanding of regulating system problems will be effected by doing so.

In addition to providing a means of understanding regulating system fundamentals, the Bode diagram also is useful in the design of regulating systems. The advantages and disadvantages of the Bode diagram as a design tool have been indicated.

Because of its general usefulness in understanding and in designing regulating systems, a familiarity with the Bode diagram should prove valuable to anyone concerned with the use of regulators in industrial control.

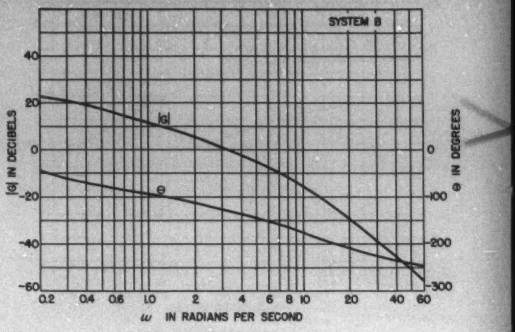


Fig. 10. Bode diagram for system B.

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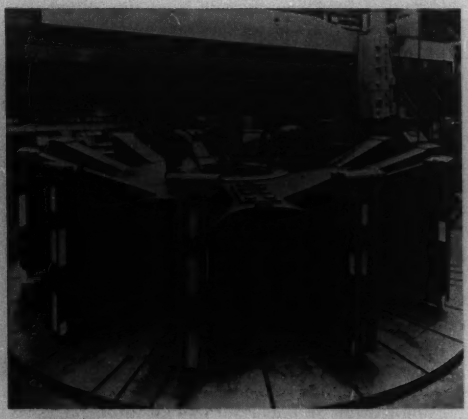
Water Wheel Generator for Niagara Project



The first of thirteen 167,000-kva water wheel generators to be used in $720 million New York State Authority's Niagara power project is near completion in the Westinghouse Electric Corporation's East Pittsburgh, Pa., plant.

With a maximum installed capacity of 1.9 million kw at the main generating plant, the Niagara project will be the largest hydroelectric project east of the Mississippi River and the second largest in the United States. Only Grand Coulee in the State of Washington has a greater capacity.

Craftsmen who operate the 40-foot boring mill are shown checking the dimensions of the "spider." The "spider" is 27 feet in diameter and weighs 50 tons. The 50-ton shaft will be shipped to the project site at Lewiston, N.Y., when operations on the 96-inch engine lathe are completed. The shank diameter of the shaft is 50 inches.

Shipment of the parts for only one of the 120-rpm generators, not including the water wheel, will require 34 railroad cars. Installation of the first unit is scheduled to begin early in 1960. Westinghouse will ship the last of the 13 umbrella-type water wheel generators early in 1961.

Rationalization of Electrical Clearances at EHV's 230 Kv to 460/500 Kv

P. L. BELLASCHI
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The basic approach is developed that switching surges, in combination with 60-cycle operating voltage, are primary factors determining electrical clearance requirements at the higher voltages. Clearances presented are discussed and compared with reference to current design values and practices.

WITH the extensive application of 230 and 345 kv, and the advent of still higher transmission voltages (460/500 kv), the economic urge for further rationalization in station and line design makes itself felt to a point that additional studies and research become inevitable.

There are three conditions of service to consider in determining the electrical clearance requirements for high-voltage stations:

1. 60-cycle voltages.
2. Switching overvoltages.
3. Lightning.

At the higher operating voltages, attention must also be given in the station design to corona and radio-noise effects; for these will affect the electrode and terminal arrangement, and thus influence to some measure the electrical clearances. It is assumed here that due allowance will have been made in the design for such additional requirements as may be imposed by mechanical forces and similar effects.

In this study, recourse was made to basic data on the strength of air and also to the use of other engineering data pertinent to the problem, such as are available. In this connection, some of the more significant sources are given in the references, but the list is not to be construed by any means as all inclusive.

The factors which determine the electrical-clearance requirements for high-voltage stations will be considered in their order of importance: (a) switching overvoltages; (b) 60-cycle operating voltage including corona effects; and (c) lightning.

CLEARANCES TO GROUND

FIRST, WE SHALL DETERMINE the insulation in the station from line-to-ground in terms of standard-rod-gap spacings required to withstand the maximum switching overvoltages. The criteria on which the derivation is based are as follows:

1. The line-to-ground 60-cycle voltage is 5 per cent above rated voltage.
2. The maximum switching overvoltage in the station from line-to-ground is taken not to exceed 2.75 times the line-to-ground crest.
3. The multiplying factors consist of: (a) A ratio of 1.15 for impulse-to-switching; (b) A withstand-to-critical flashover of 1.15; (c) An allowance of 1.10 for nonstandard atmospheric conditions; and (d) A factor of safety of 1.15.

A switching overvoltage of $2.75 \times E_{LN}$ in the station is amply high for systems of modern design considered here. The multiplying factors applied likewise can be considered conservative. Thus, the equivalent standard-rod-gap spacings required to withstand switching overvoltages $2.75 \times E_{LN}$ are derived and are given in column 5 of Table I. The derivation is based on a positive wave which results in greater clearance requirements to withstand switching surges of positive polarity.

In a station, busses and insulator supports entail a dissymmetry of the electric field from the line to ground (earth), which has the effect to lower the positive voltage flashover. For instance, the positive impulse wave ($1\frac{1}{2} \times 40$ *MS*) flashover voltage for a standard rod gap and the corresponding impulse flashover voltage for a rod-to-plate electrode arrangement are in the ratio of 1.00 to 0.88 for the same spacing, in the range of spacings from 60 to 100 inches.[1] This dissymmetry effect has been referred to as the electrode factor. Thus, applying an electrode factor of 1.12 to the equivalent standard-rod-gap spacings in Table I, the minimum clearances to ground required for the station-bus to withstand a maximum switching overvoltage of $2.75 \times E_{LN}$, for the criteria of design stated, are respectively 67 inches for 230 kv, 84 inches for 288 kv and 102 inches for 345 kv (Table II). For a 460/500 kv station-bus design, the minimum clearance to ground is 140 inches (Table III).

All clearances are between conducting electrode parts, from line to ground (earth). Altitude is assumed here not to exceed the reference value of 3,300 feet (1,000 meters). Stations located at higher altitudes may require additional allowance in the clearances used.

In Fig. 1 are plotted the electrical clearances phase-to-ground for 230 to 460/500 kv stations.

Essentially full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y. Feb. 1-6, 1959. Recommended for publication by the AIEE Substations Committee.

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In the preparation of this article, the author has of necessity drawn in good measure from his knowledge and association as a consultant to the Bonneville Power Administration and gratefully acknowledges use of various materials presented.

CLEARANCES BETWEEN PHASES

THE PHASE-TO-PHASE CLEARANCES of the station bus as determined here are based on maximum switching overvoltages which appear between the phases. Maximum overvoltages phase-to-phase will result from surges of high value and opposite polarity occurring simultaneously on the adjacent phases.

Actual field measurements on switching overvoltages between phases, and for that matter corresponding data from transient analyzer studies, are limited. Therefore, in this area, one must rely on experience in combination with such field data as are available, in addition to analysis and good judgment. We cannot escape the fact that some assumptions must be made. That is, the results obtained at this time are susceptible to further refinements later when more basic data on switching surges will become available. The following can be considered reasonable assumptions:

Case 1. Overvoltage one phase = +2.5 or +2.0 E_{LN}
Overvoltage on adjacent phase = −1.0 or −1.5 E_{LN}
Maximum phase-to-phase 3.5 E_{LN}

Case 2. Maximum phase-to-phase 3.75 E_{LN}

Case 3. Overvoltage on one phase = +2.5 or +2.0 E_{LN}
Overvoltage on adjacent phase = −1.5 or −2.0 E_{LN}
Maximum phase-to-phase 4.0 E_{LN}

Case 4. Maximum phase-to-phase 4.5 E_{LN}

On the strength of available data and experience, Case 1 corresponds to the lowest maximum overvoltage that can be assumed at this time. An overvoltage between phases of 4.0 × E_{LN} (Case 3.), however, is more realistic for practical application at the present state of the art.

A simplified method of derivation is used to start with. It is approximate and consists in proportioning the clearances between phases to the phase-to-ground clearances in the ratio of the switching overvoltages. An example of this simplified method is shown in Table IV. The clearances corresponding to each of the four overvoltages: 3.5, 3.75, 4.0 and 4.5 E_{LN} are given in the tabulation for comparison purposes.

In the simplified derivation of the clearances between phases given in Table IV, one will note that all the multiplying factors have been applied, including the electrode factor of 1.12. It will be recalled this factor was introduced to account for the effect on flashover of the dissymmetry of the electric field which exists from the bus electrode to ground. However, the electric field of the voltages between phases possesses a higher degree

Table I. Standard Rod-Gap Spacing to Withstand Switching Overvoltages (2.75 E_{LN})

Voltage Class	Line to Ground Voltage Crest (kv)	Switching Overvoltage 2.75×60 Cycle Crest (kv)	Multiplying Factors: Impulse/Switching =1.15 Nonstand. Atm. =1.10 Withstand/F.O. =1.15 Factor of Safety =1.15 (kv)	Equiv. 1/2-Inch Rod Gap* (Pos. Wave) (inches)
230 (242)	198	545	915	60
288 (302)	248	680	1,140	75
345 (362)	296	815	1,360	91

*From curve designated New Rod Gap in Fig. 4 of Reference 2.

Table II. Electrical Clearances to Ground for Station-Bus Design (see Table I)

Voltage Class	Column 4 Table I (kv)	Equivalent 1/2-Inch Rod Gap (Pos Wave (inches)	Min. Clearance To Ground Station-Bus Design* (inches)
230	915	60	67
288	1,140	75	84
345	1,360	91	102

*Electrode factor = 1.12.

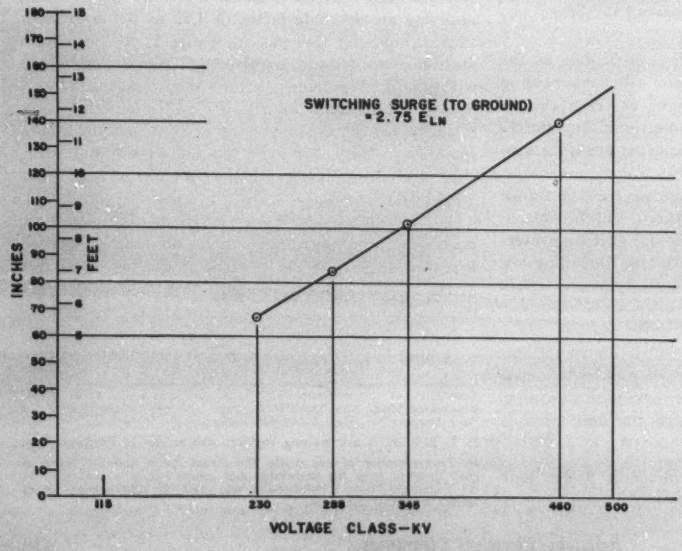

Fig. 1. Electrical clearances phase-to-ground for station bus, co-ordinated to switching surges and 60-cycle voltages.

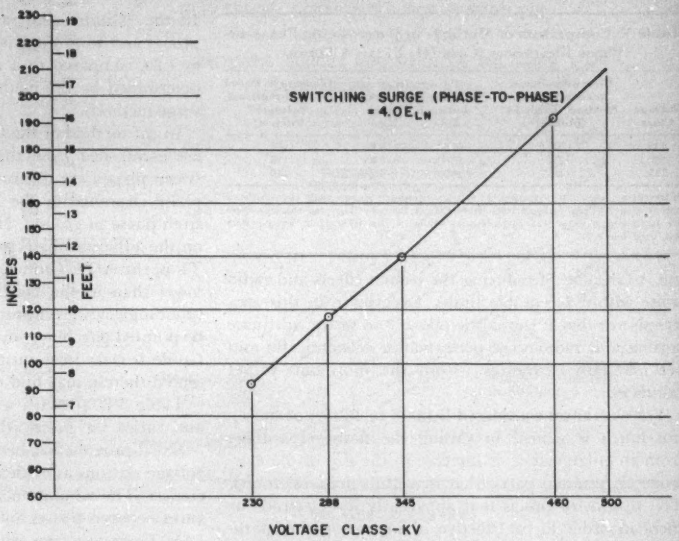

Fig. 2. Electrical clearances phase-to-phase for station bus, co-ordinated to switching surges and 60-cycle voltages.

Table III. Electrical Clearances for 460-Kv Station-Bus Design

Minimum Clearance Phase-to-Ground*					
Voltage Class (kv)	Line to Ground Crest (kv)	Switching Overvoltage E_{LN} = 2.75 × 60 Cycle Crest (kv)	Multiplying Factors: Impulse/Switching = 1.15 Nonstand. Atm = 1.10 Withstand/F.O. = 1.15 Factor of Safety = 1.15 (kv)		Equiv. Std. Rod Gap (Pos. Wave) (inches)
460 (483)	395	1,090	1,825		125

Minimum Clearance Phase-to-Phase*		
Switching Overvoltage E_{LL} = 4.0 × 60 Cycle Crest Voltage		Multiplying Factors Applied Same as Above (kv)
One Phase, E_{1G} = +2.5 or +2.0 x 60-cycle crest Adjacent Phase, E_{2G} = −2.0 × 60-cycle crest		2,660

Symmetrical Voltages between Phases— Rod Gap Characteristics		Clearance Based on Symmetrical Voltages (inches)	Rod-Gap Spacing Corresponding to +2,660 kv (inches)	Minimum Clearance Phase-to-Phase (feet)
E_{1G}	E_{2G}			
+1,660 kv	−1,000 kv	180	192	16 (15)
+1,330 kv	−1,330 kv			

*Spacing determined from experimental data in references 2 and 7. For the large spacings, Hagenguth rod-gap data was used.

of symmetry than exists in the case from phase-to-ground for two reasons. First, because the electrode arrangement is more symmetrical as such; and second, because the voltages applied to the adjacent phases are of opposite polarity and are equal or closely equal in magnitude with respect to ground (earth).

Thus, taking into account the higher degree of symmetry of the electric field which exists phase-to-phase, the phase clearances corresponding to an overvoltage between phases of 4.0 × E_{LN} (Case 3.) are derived and presented in Tables III and V. The tabulation values are plotted in Fig. 2 which cover the range of voltage classes from 230 kv to 460/500 kv. On this basis, the phase clearances metal-to-metal for 230 kv, 345 kv and 460 kv are respectively 92 inches, 140 inches, and 192 inches.

A factor of importance in station-bus design is the ratio of the two clearances, between phases and from phase to ground. By this method (Tables II, III and V), the ratio of the two clearances is 1.37 for each of the 3 voltage classes; i.e., 230 kv, 345 kv and 460/500 kv.

60-CYCLE VOLTAGES, CORONA, AND RADIO NOISE

THE DESIGN of the insulator supports for the station bus must, of course, fulfill the mechanical requirements and provide the creepage surface necessary to withstand the voltages encountered in service under service conditions such as rain, etc. For usual service conditions in which atmospheric contamination and similar factors are not severe, the minimum clearances from bus to ground in Tables II and III are quite adequate, with minor adjustments made in providing the space required for the insulator supports.

At the higher voltages, more attention must be given to the design of the electrode parts, of the air switches,

Table IV. Electrical Clearances between Phases

Voltage Class	Column 4 Table I (kv)	Minimum Clearance To Ground (inches)	Minimum Clearance between Phases* Maximum Surge Phase-to-Phase Case I (3.5)	Case II (3.75) (inches)	Case III (4.0) (inches)	Case IV (4.5)
230	915	67	85	91	97 ×	110
288	1,140	84	107	115	122	138
345	1,360	102	130	139	148	167

*Example: 345-kv voltage class; Case III, E_{LL} = 4 times; clearance to ground = 102 inches.
Phase-to-phase clearance = 102 x 4.0/2.75 = 148 inches.

Table V. Comparison of Methods in Determining Phase-to-Phase Clearances (Case III, E_{LL} = 4 Times)

Voltage Class	Clearance Based on Simplified Method, Table IV (inches)	Symmetrical Voltages between Phases E_{1G}	E_{2G}	Clearances Based on Symmetrical Voltages* (inches)
230	97	+670 kv	−670 kv	92
288	122	+830 kv	−830 kv	118
345	148	+990 kv	−990 kv	140

*Clearances based on symmetrical voltages between phases and characteristics approaching rod gap (symmetrical). Note that at the very large gap spacings there are uncertainties as to what experimental values to use (Hagenguth rod-gap data was used here).

etc., to the end of reducing the corona effects and radio noise within acceptable limits. Experience in this area has shown that it should be possible to secure adequate corona and radio-noise performance economically and yet maintain clearances within the minimum values tabulated.

For clearances considered here (8 to 16 feet or more), not much is gained in raising the flashover voltage from an enlargement or increase in the size of the electrode or terminal parts; that is, within practical limits. The reason for this is that apparently the electrode as such, in order to be effective in increasing the sparkover voltage, must approach in relative size the sparkover distance, i.e., it must be greater than about one third the sparkover distance.[1,3]

While no detailed corona studies have been made of the requirements for very-high-voltage stations, such as 460/500 kv, a bus design consisting of a bundle-conductor arrangement does appear practically necessary at the very high voltages.

INFLUENCE OF LIGHTNING ON STATION CLEARANCES

THE ACTUAL impulse withstand voltages corresponding to the minimum clearances to ground in Tables II and III come close to and, in fact, are practically the same as the basic impulse insulation levels (BIL's) specified in present-day station design. Extensive studies and experience with high-voltage stations substantiate the adequacy of these impulse insulation levels in providing good co-ordination and protection to the station against lightning.

In like manner and even more so, the minimum clearances between phases in Tables III and V should be more than adequate from a lightning-protection standpoint. For, in the case of lightning, there is little or no evidence in support of the presence of impulse voltages of high value and opposite polarity appearing simultaneously on the adjacent phases in a high-voltage station.

COMPARISON TO PRESENT PRACTICES

THE INSULATION TO GROUND in high-voltage stations is well established from the BIL requirements and the system overvoltages, as discussed previously. Therefore, a good criterion in comparing clearances in station designs is the ratio of the clearances between phases and to ground.

In Table VI are reproduced the clearances recommended in the "AIEE Guide for Minimum Clearances." In the "Guide," the ratios of the clearances between phases and to ground is an average of 1.24 and as low as 1.20, compared to a ratio of 1.37 for the clearances determined by the method of this analysis (switching-surge method).

In the method of the Guide, the clearances to ground are established from the BIL's and the clearances between phases are determined by opening the phase-to-phase clearance to the point so that flashover occurs from phase to ground. However, the voltage conditions on the adjacent phases are not specified in this method. Thus, the AIEE Guide gives ratios that are 10 per cent lower than in the switching-surge method, and correspondingly lower clearances between phases. It should be pointed out, however, that the language of the AIEE Guide is clear in pointing out that the clearances presented therein may find difficulty in their acceptance.

Table VII presents and compares phase clearances and ratios for present-day 345-kv station designs.

Much progress has been made in the design of high-voltage stations as evidenced in Table VII and the references. The tabulation shows a trend to reduced clearances between phases and to a lower ratio approaching 1.35. There are cases where system conditions and the character of the load served may dictate the highest degree of reliability against all possible phase faults, in which case, higher ratios would be justified.

This study points up the need for further investigations and rationalization of the basic problems in high-voltage station design.

AREAS FOR FURTHER STUDY

MANY FACTORS combine in the insulation design of a high-voltage station. With a more complete knowledge of each factor and of their interrelation, pyramiding of margins and excessive allowances can be reduced and corresponding economies should be possible.

Fig. 3 suggests an area in which further rationaliza-

Table VI. Minimum Electrical Clearances Metal-to-Metal According to AIEE Guide[3]

Kv Class	BIL Level Kv Withstand	Minimum Clearance To Ground (inches)	Minimum Clearance between Phases (inches)	Ratio of Clearances between Phases and to Ground
230	825	65	80	1.23
	900	71	89	1.25
288	1,050	83	105	1.27
	1,175	94	113	1.20
345	(1,300)	(104)	(118)	(1.24)

Table VII. Comparison of Phase Clearances Minimum Metal-to-Metal and Ratios for 345-Kv Station Designs

System	Reference	Phase Clearances	Ratio of Clearances between Phases and To Ground
AEP	11	14 feet	1.40
AEC	12	18 feet	1.80
BCE	14	13.25 (1955 Design)	1.33
		10.0 (1957 Design)	1.33
BPA		14 feet 8 inches Possible Reduction (Future)	1.73
Tables II & V		11 feet 8 inches Possible Reduction (Future)	1.37

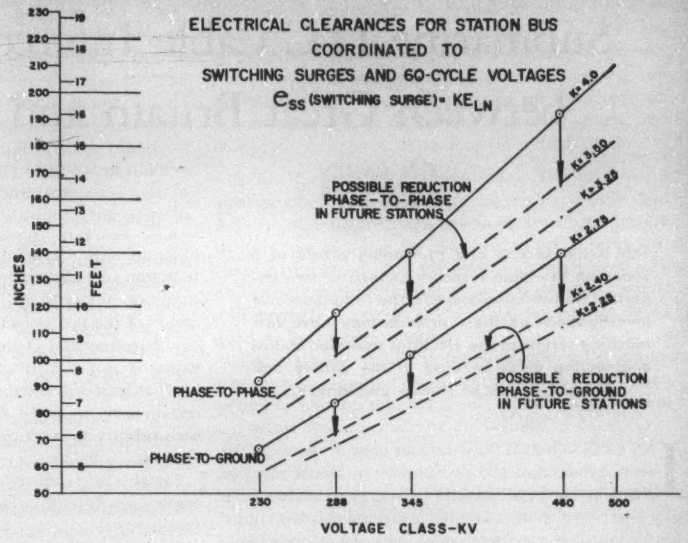

Fig. 3. Electrical clearances for station bus; possible reductions in future stations.

tion and significant economies should be possible; i.e., additional reductions in the clearances of high-voltage stations should be possible with improvements and advancements in system design, in circuit interruption and protection of service, in better knowledge of the voltages developed and insulation, and with more experience.

Additional field studies and transient analyzer studies are required to further our basic and working knowledge on switching surges, both in regard to phase-to-ground and phase-to-phase. In this same connection, more high-voltage laboratory studies and investigations are necessary on the performance of station insulation to switching surges, both in regard to phase-to-ground and phase-to-phase when simultaneous surges and 60-cycle voltages on the respective phases are applied. The need in these two areas is pressing and urgent.

In brief, it should be possible to effect additional reductions in present clearances upon better understanding of the problems and factors in the areas outlined for further study and development.

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Submarine D-C Cable Interconnection between Great Britain and France

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This is the second and concluding article of a series on the main research aspects of two important transmission projects. The comprehensive investigations on these projects may have far-reaching results in the electrical and mechanical engineering fields because of the variety and general interest of studies undertaken.

INTERCONNECTION systems permit pooling reserve production and provide the means of making the best use of all sources of energy available in a given territory. With a view to achieving this aim, most large countries have, therefore, developed extensive high-voltage systems, on a national level, which have often been extended on an international scale. In Europe, in particular, this concept of generalized interconnection has progressively reduced the influence of political frontiers on the development of high-voltage systems, and the territorial confines of the various countries tend to disappear on maps of the European system. Thus, France is linked with all the adjacent countries, but so far a natural barrier, the Strait of Dover has prevented the establishment of similar interconnection between the British and French systems owing to the technical difficulties inherent in overcoming this barrier.

Now, there are interesting systematic diversities between the means of production and load curves in France and Great Britain.

Whereas in Great Britain electricity is generated almost exclusively by steam plants scattered throughout the country close to the centers of consumption, France has large hydraulic resources which, at the present time, represent approximately one half of the total annual production of electric energy and have necessitated the development of a transmission system capable of carrying this energy to the centers of consumption.

This diversity involves very significant differences between production costs and between the means of production available at different times of the day and year, and justifies contemplating economic exchanges of energy between the two systems and extension of the advantages already obtained in France by the interconnection of mixed resources.

Moreover, the peak demands on the two systems also present a systematic diversity, particularly so because of different official local time during part of the year, different national habits, working hours, climate, distribution of industrial, commercial, and domestic consumption of electricity. This diversity between the load curves of the two systems, is yet another factor in favor of interconnection of the latter, for the diversity to be expected is presently of the order of 400 megawatts (mw) at least and interconnection would make possible certain savings on the capital investments necessary in each country to meet the separate demands of the two systems.

Finally, interconnection can bring considerable advantages in case of an accidental diversity between the two systems.

As early as 1949, these possibilities attracted the attention of the Électricité de France and the British Electricity Authority (later the Central Electricity Authority and then Central Electricity Generating Board), who created a Joint Study Committee to clarify the economic advantages and technical possibilities of carrying out such a project.

EVOLUTION OF STUDIES

FROM THE VERY BEGINNING, the Committee directed its efforts to calculating the savings which could be obtained from the contemplated interconnection, both in capital investments and in operating expenses. In particular, the savings which could be achieved by properly organized exchanges of energy between the two countries were analyzed in detail by the British and French operating departments which, in constant touch with each other, regularly exchanged the necessary information on daily load curves and marginal generating costs, estimated hour by hour, so as to proceed to an "hypothetical operation" of the projected interconnection.

Favorable results of these studies led the Joint Study Committee to recognize the advantage of the interconnection and recommend that a program of tests be carried out with a view to solving the special technical problems raised by the laying of submarine power cables under the strait. Allowing for the variations of the financial return with the rated capacity of the link and the possibilities of available cable techniques, the characteristics adopted for the interconnection to be studied were fixed at 132 kv and 100 to 200 megavolt-amperes (mva), alternating current. At that time, although the possible advantages of using direct current were recognized, this method was not considered for adoption owing to the lack of industrial experience in this field.

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Within the framework of the program laid down, research, studies, and tests, the principal features of which are given in the following paragraphs, were continued for several years so that by the end of 1955 agreement was reached on the types of cables and accessories to be used and the conditions to be met for the manufacture, laying, and operation of these cables.

However, this first stage did not lead to any positive work, owing to the progress made in the meantime in the field of direct-current transmission. This progress had assumed concrete form by the commissioning on an industrial scale of the 20-mw, 100-kv link, between Sweden and the Island of Gotland. The favorable results achieved and subsequent progress in the development of high capacity mercury vapor valves led the Committee to consider once again the adoption of direct-current transmission for the cross channel interconnection.

A comparative economic and technical study as between alternating current and direct current was thereupon taken up once again on the basis of the new data available.

Finally, in May 1956, the Committee recommended the establishment of a direct-current interconnector of 120 to 150 mw, at 200 kv. This choice was in particular justified by the economic advantage of direct-current transmission and also by various technical advantages such as possibilities of future extension, simplification of cables and repair problems, reduction in the number of cables and consequently less encumbrance of the seabed and less risk of damage from external origin, elimination of the problems of synchronous operation of the systems, possibility of following a route which, while slightly longer, is less exposed to hazards due to intensive fishing, and further away from the route of the existing telecommunication cables.

THE ALTERNATING-CURRENT PROJECT

As most of the features of this original project have already been defined in earlier publications,[1,2,3] we shall confine ourselves to giving some information on the research undertaken in France to collect the technical data necessary for determining the specification of the cables and contributing to a solution of the special problems raised by their manufacture, laying, and operation. This program was based on the execution of numerous tests in the laboratory, on the system, and in the sea, completed by various theoretical studies.

Research on Cable Specification. Comparison of various existing techniques of high-voltage cable had led the Joint Study Committee to make a first selection of two types of cables for the project: pre-impregnated gas-filled cable, on account of its simplicity and suitability for manufacture in long continuous lengths; and external gas compression cable, on account of its good dielectric performance.

The main object of the tests undertaken in France was to make an objective comparison of these two competing techniques selected by the Joint Study Committee with a view to making a final choice.

The four large French cable manufacturers with well-established experience of very-high-voltage cables were associated in the corresponding research. Supplementing the tests made in the laboratories of these cable manufacturers, Électricité de France at its Fontenay Research and Testing Center undertook a program of investigations on cables of both types with their accessories (in particular, flexible joints), designed for transmission capacities of 100 and 200 mva. These tests, which covered a large number of samples, can be classified as follows:

1. Conventional dielectric tests at industrial frequency, to ascertain the withstand level of the various samples.

2. Dielectric stability tests, made on long samples and flexible joints (120 meters (m), about 130 yards) at 1.7 times the rated service voltage, by connecting to the phase voltage of the 225-kv system, with superimposed daily heating cycles.

3. Dielectric tests on certain short samples (18 m, about 20 yards), including flexible joints, at 2.9 times

Fig. 4. Partial view of the 132-kv submarine cable being tested on the 225-kv system at the Fontenay Research and Testing Center.

Fig. 5. Device used to check the mechanical behavior of submarine cable sheaths under repeated flexing, simulating the conditions during repairs at sea.

Fig. 6. Floating drum used for the laying of the second trial cable at Boulogne-sur-Mer.

the rated voltage, by connecting to the line voltage of the 225-kv network.

4. Mechanical tests to check the behavior of the cables under the main types of stresses to be expected during handling, laying, or repairs. Under this head, the following tests were made: (a) bending tests on cables and flexible joints under mechanical tension, to simulate passage over the machinery of cable-laying ships; (b) tension-torsion tests to check the behavior of the cables under considerable strains; (c) tests to check the ability of the cables to withstand external pressure, to reproduce the conditions met with when repairs are made, owing to the necessity of eliminating the gas pressure which in normal service offsets external hydrostatic compression; and (d) repeated flexing tests to study the behavior of the sheaths under the influence of the stresses set up by movements of the boat during repairs, which are necessarily lengthy.

All these tests lasted several years and were repeated on samples of various designs. Fig. 4 gives a partial view of the station for testing cables on the system and Fig. 5 shows the device used to reproduce the stresses caused in the cable near the seabed by vertical movements of the boat during repairs.

Research Relating to Conditions of Cable Laying and Maintenance. In France the study of the conditions of cable laying and repair was confined to cables of the external gas-compression type, investigations on pre-impregnated pressure cables being carried out in Great Britain.

The corresponding work consisted essentially in sea trials in the neighborhood of Boulogne-sur-Mer, in two successive phases:

1. In a series of trials, begun in December 1953, a length of about 440 m (480 yards) of cable with a cross-section of 123 square millimeters (mm^2) (242 MCM) was laid from a barge. This length consisted of four samples joined by flexible joints and terminated by a stop-end joint. (This first series of trials brought out several weaknesses in the cable specification tested, particularly with respect to the cross-section of the conductor, the nature of the sheath reinforcements and their protection against corrosion, and the flexible joints.)

2. A second series of trials, initiated at the end of 1954, was made on a length of 1,400 m (about 0.87 mile) of cable with a cross-section of 380 mm^2 (750 MCM). The cable and flexible joints designs had been worked out in the light of experience gained in the preceding tests.

The test cable was laid by means of a floating drum (Fig. 6), a reasonably accurate reproduction of the drum previously used for laying oil-filled cables of the flat type between Sweden and Denmark. Various improvements had been made in the drum following preliminary tests at Boulogne-sur-Mer. The essential advantage of this method is that the cable is not subjected to the twisting involved when the cable is coiled in the tanks of a cable ship.

The operation was successfully carried out by the use of tugs, and numerous experiments were made with the new test cable, which remained in the water for about a year. The experiments included, in particular: (1) dielectric tests; (2) experiments for detecting and locating gas leaks and dielectric faults; (3) inspection of the cable on the sea bottom by divers and frogmen; and (4) making of several repair joints under various conditions.

The lessons learned during the operations at sea were completed by investigations in the laboratory on the cables recovered after these trials.

In addition, in connection with work done on medium-voltage submarine cables connecting certain islands off the French coast with the mainland, the study of methods of detecting cables on the sea bottom and locating their faults was continued and led to the development of suitable equipment and methods.

Other Important Studies. The parallel operation of two such highly developed interconnected systems as those it was projected to link up raised the problem of the extent of fluctuations likely to occur on the link and their effect on the heating of the cables. Far-reaching tests were made jointly by Électricité de France and the Central Electricity Authority to investigate these problems, and included:[4,5]

1. Tests for determining the power-frequency characteristics of the two systems under different operating conditions.

2. Tests for recording the difference between the effective frequencies in the two countries, each of them regulating to maintain its frequency at 50 cycles per second. (On the basis of the results of these two first tests, it was possible to plot the curve of the power fluctuations which would have occurred on the interconnection if the two systems had been linked during the period of the tests.)

3. Tests in France to measure the temperature rise in immersed thermal images of 100- and 200-mva cables. These thermal images had been especially developed for this purpose and were traversed by currents corre-

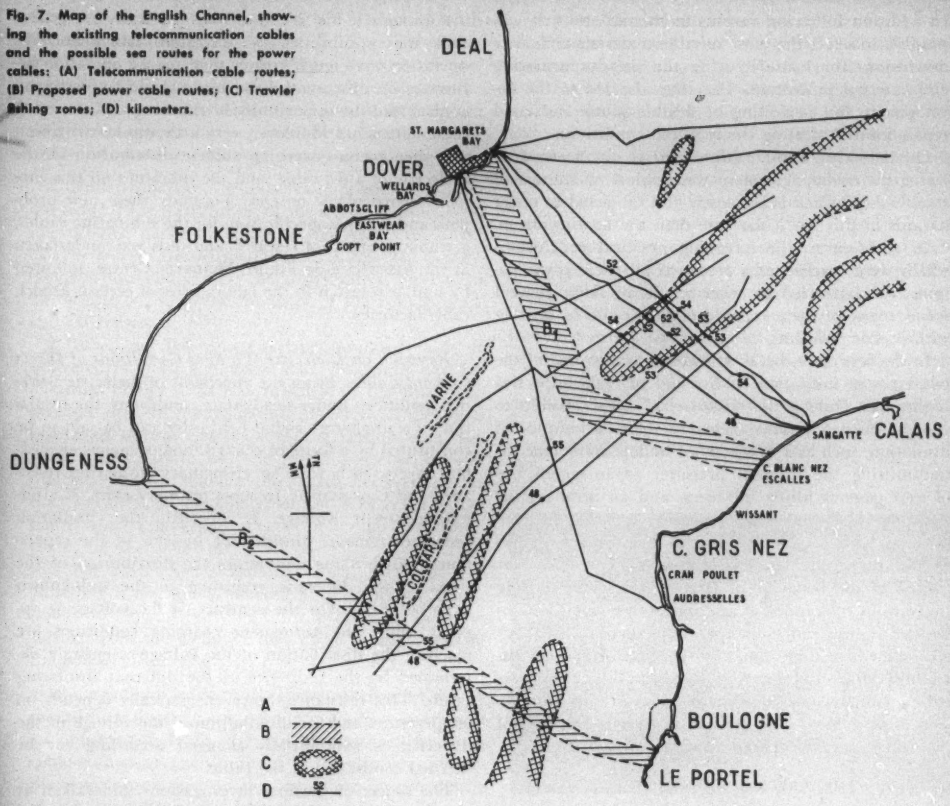

Fig. 7. Map of the English Channel, showing the existing telecommunication cables and the possible sea routes for the power cables: (A) Telecommunication cable routes; (B) Proposed power cable routes; (C) Trawler fishing zones; (D) kilometers.

sponding to the superposition to various programs of transfers of the fluctuations of power deduced from recordings of the differential frequency.

These experimental investigations were accompanied by theoretical studies, particularly on the behavior of the cables under transient thermal conditions.

Among other complementary studies carried out during the preparatory work on the France–England interconnection, the following may be cited: (1) theoretical studies of the electrical operating conditions of a submarine power link using spaced single-core submarine cables;[6] (2) studies of the availability of the interconnection link allowing for probabilities of faults resulting from external causes (trawling, anchors), in the light of the experience gained in connection with telecommunication cables; (3) studies relating to the pressurizing from the terminals of long gas-pressure cables; and (4) investigations for the choice of the most favorable route.

Conclusions Drawn from Studies and Research Relating to the Alternating Current Project. As a result of all this research work and that done along parallel lines in Great Britain, agreement was reached between the two countries on the technical feasibility of a 200-mva 132-kv interconnection, and on the principal characteristics of the cables to be used.

For this particular project, the type of cable selected was the preimpregnated gas-pressure cable, with a few alternatives in the specification on either side of the English Channel. The link was to be constituted by four single-core cables (one of them as a spare cable) placed at least 500-m (550-yards) apart, along a route shown by a broken line between Dover and the Cran d'Escalles, about 43-km (27-miles) long (Fig. 7).

The cable preferred in France was to have a conductor partially constituted by hollow wires to transmit the gas pressure. The advantage of this method is that it avoids the use of a loose lead sheath and of a conductor with a large central duct which may increase the risks of water penetration into the cable in the event of serious damage. Moreover, research in France demonstrated the advantage of using a mixture of nitrogen and sulphur hexafluoride,[7,8] for filling the cables.

In addition following various mechanical tests, it was possible to select the most suitable materials and their dimensions for manufacturing the sheaths, armoring and external protection. The tests also led to the development and perfecting of flexible joints and rigid repair joints[7,9] meeting the required conditions.

On the other hand, with regard to the method of laying the cables, agreement was reached on the use of a cable-ship, which is less costly and subjected to fewer hazards in this particular case than the floating drum.

In addition to the foregoing practical conclusions which were reached as a result of all these investigations, the latter led to other results of more general scope, many of them capable of future use in dealing with similar problems.

In the first place, better knowledge was gained of the two types of insulation studies and of their respective limitations. During the tests, it had been possible to propose certain improvements in these techniques of insulation, such as a new type of hollow conductor for transmitting the internal pressure, advantageous use of new gaseous filling mixtures, and an arrangement avoiding migration of impregnation material in compression cable conductors[7]. In the second place, thanks to the numerous sea trials, greater experience was gained of the behavior of large power cables during the various operations at sea and of the conditions to be met to carry out these operations successfully. They also offered an opportunity to perfect methods of detecting cables and locating their faults.[10] They contributed to the advancement of many studies on subjects of permanent interest, such as thermal behavior of the cables, parallel operation of large systems, etc.

THE DIRECT-CURRENT PROJECT

Recommendations made by the Joint Study Committee in 1956 in favor of the direct-current project directed the research work undertaken by France within the framework of this project into new channels. This research applied essentially to direct-current cables, and from now on we shall deal exclusively with these. The development of the terminal conversion equipment for this first project is being left to the Swedish industry, at present recognized to be the only one with the necessary qualifications and experience for undertaking a project at the contemplated scale. For this reason, the studies made in France in connection with this d-c transmission were limited mainly to the determination of the characteristics of certain parts of the terminal stations, such as transformers, means of supplying the necessary reactive energy, investigations on the problems of harmonics, and radio and television interference.

With regard to the cables, half of which were to be supplied by French industry, better knowledge of the behavior of available types of insulation under the conditions to be met was necessary. In particular, polyethylene-insulated cables which were not suitable for the a-c project looked very attractive for d-c and deserved special attention.

Although it had hitherto been generally recognized that the possibilities of insulated cables for d-c operation were much greater than for a-c operation because of the absence of dielectric losses, few experimenters had had the opportunity of checking and clarifying these statements. Moreover, very little was known about the phenomena governing voltage distribution in the dielectric of a d-c cable, and the literature on this subject is particularly meager. To study these new problems and set up a specification for the submarine cables, a whole program of research and tests was undertaken at the Électricité de France Fontenay Centre, followed by similar research in the laboratories of certain French cable factories.

Research on Dielectric Working Conditions of Direct Current Cables. From the viewpoint of dielectric working conditions under steady-state conditions, the insulation of a single-core radial field cable can be said to be constituted by a series of coaxial, homogeneous elementary layers, each with an elementary insulating resistance and capacitance. In most ordinary cases, if alternating-current voltage is applied, the insulation resistance remains considerable in view of the capacitance, which alone determines the distribution of the stress in the dielectric according to the well-known hyperbolic law. On the contrary, if d-c voltage is applied, when the permanent charging conditions are reached, the distribution of the voltage is entirely determined by the resistance of the different insulating layers. This resistance, however, generally depends on temperature, and the distribution of the voltage in the dielectric is substantially changed according to the thermal conditions in the cable.

The object of the first investigations undertaken at the Fontenay Centre[11] was to make an experimental study of the influence of temperature on the insulation resistance of cables with impregnated paper insulation and cables with polyethylene insulation, from which the behavior of these cables could be deduced when subjected to given thermal conditions.

From measurements made on samples of cables and on polyethylene sheets, it has been possible to bring out the following laws, which seem to give a sufficiently close approximation of the phenomena observed.

1. The resistivity of the impregnated paper under steady-state conditions varies as a function of the temperature according to a law of the form $\rho = \rho_0 e^{-a\theta}$ in which θ is the temperature in degree centigrade and α a characteristic coefficient of the insulating material (usually comprised between 0.09 and 0.11).

2. The resistivity of polyethylene under permanent operating conditions also varies with the temperature according to a law of the form $\rho = \rho_0 e^{-a\theta}$ (with $\alpha = 0.13$ in the first experiments carried out). This coefficient will probably vary according to the nature of the polyethylene used.

3. The resistivity of the impregnated paper does not vary much with the voltage applied, but that of polyethylene is a decreasing function of the voltage and,

therefore, of the applied stress S, in accordance with the approximate law: $\rho = k/S^{\gamma}$ (with γ approximating 2).

On the basis of these elementary laws, the distribution of the stress in the dielectric of a cable under given thermal conditions can be calculated. Essentially, the following results are found:

1. Under conditions of uniform temperature (cables not loaded) the distribution of the stress in cables with impregnated paper insulation is the same with direct current as with alternating current; in the case of polyethylene-insulated cables, the distribution approaches uniformity owing to the influence of the voltage gradient on resistivity.

2. When an impregnated paper-insulated cable is subjected to given permanent load conditions, the distribution of the stress is a function of the total temperature drop in the insulation, therefore of the losses dissipated by the conductor. For a certain load, the stress is substantially uniform in the dielectric, beyond this load the stress under the sheath becomes greater than the stress on the conductor and may reach values higher than that which appears under no-load conditions near the conductor.

3. For polyethylene-insulated cables, the stress distribution is not much affected by the thermal conditions and remains fairly uniform in a loaded cable resulting from the compensating effect of the stress on the polyethylene resistivity.

If a maximum value of the stress, which must not be exceeded, is fixed for the outside insulation layers of a paper-insulated cable, the power transmissible by a cable with given characteristics is, therefore, limited by the temperature drop in the insulation, independently of the limitations of temperature of the conductor. This is an important difference as compared with alternating-current cables where only the temperature of the conductor has to be considered. Moreover, it is to be noted from this point of view that external cooling of a cable does not increase this limit, since it does not change the internal temperature drop. On these bases, the specification most suitable for solving a given problem, technically or economically, can be worked out according to the various parameters involved.

Experimental Studies of Direct-Current Cables. Without going into the details of the experimental program which is still being carried out and, in view of the novelty of the subject, will certainly be followed by numerous other experiments, it will be of interest to give a brief description of some of the tests made and the essential data gathered from them:

In order to verify the phenomenon of the transfer of the maximum gradient to the outside layers of the insulation when the load on the cable exceeds a certain value, several experiments were made on samples of paper-insulated cable subjected to different thermal operating conditions (different currents, different cooling conditions) and tested under direct current to breakdown. It was thus possible to determine that breakdown occurred at a substantially constant maximum stress (calculated on the aforementioned bases).

2. The initial tests appear to show that the application of pressure within the dielectric of a cable does not very appreciably improve its d-c withstand level. As a matter of fact, a similar remark can be made with regard to resistance to impulses. However, this important question will be the subject of additional investigation.

3. Tests made on impregnated paper-insulated cables of various types have shown that the maximum breakdown stress to be expected with these cables might reach 1,200 to 1,500 kv per cm. In the polyethylene-insulated cables tested, the levels found at room temperature give an average breakdown stress of the order of 500 kv per cm. Moreover, these cables show a certain decrease of the d-c withstand level when the temperature rises. But the tests on polyethylene-insulated cables show fairly extensive scattering.

Fig. 8. Electrostatic high-voltage d-c generator (600 kv, 4.5 ma) used at the Fontenay Center for the testing of d-c cables.

4. In addition to tests under impulse waves of different forms, tests were undertaken to check the behavior of the cables when the polarity is changed suddenly. A simplified theory shows that a rapid reversal of polarity is accompanied by an additional stress if the distribution of voltage before reversal is different from the hyperbolic distribution (corresponding to transient conditions), which appears immediately after the reversal of polarity. Therefore, it is to be expected that rapid reversals of polarity may be comparatively dangerous in polyethylene-insulated cables whether loaded or not, and on impregnated paper-insulated cables under load. The experiments have confirmed this assumption while demonstrating that in impregnated paper-insulated cables the additional risk is less serious than in polyethylene-insulated cables.

5. The tests have demonstrated the importance of the conditions of voltage rise on the dielectric test results, owing to the different phenomena of distribution under transient and steady conditions. In addition,

they have shown that breakdowns can occur after continuous application of d-c voltage for approximately one hour. Fig. 8 shows one of the d-c generators used for the previously mentioned dielectric tests (electrostatic rotating machine 600 kv – 4.5 ma).

Choice of a Cable Type. The choice of the type of cable on which the Joint Study Committee decided recently was very largely based on the foregone considerations and tests and on those made along parallel lines in Great Britain.

1. The polyethylene-insulated cable, attractive for submarine links because of the simplicity of its structure, could be contemplated for a voltage of 100 kv to sea (middle point of the earthed transmission). Nevertheless, because of some technological defects it still has which have given rise to fear of excessive risks, it has not been adopted for this first submarine crossing.

2. The impregnated paper-insulated cable of the "solid" type was finally chosen over the various types of pressure cables because of the requirements to be met in putting the cables under pressure, which are not offset by any essential dielectric advantage.

Fig. 9. Submarine self-propelling "Pegasus" (Rebikoff type) for underwater exploration.

3. The use of the sea as return conductor being out of the question, because of the risks of corrosion it would involve for the numerous telecommunication cables running under the Strait and the magnetic effect of the cable on ships' compasses, it was essential to use a circuit with go and return conductors insulated from the sea. The types of cable among which the choice could be made were: (a) the coaxial cable, the central conductor of which would be insulated for 200 kv and the outside conductor for a voltage drop of a few kilovolts (earthing of one pole of the transmission at one end); (b) twin-core cables, insulated for $\pm$100 kv (earthing of the middle point of the transmission); and (c) single-core cables, insulated for $\pm$100 kv, laid sufficiently close to each other to avoid magnetic effect of the circuit at the surface of the sea. After an economic and technical comparison of the various solutions, the last one was adopted because the cables involved are the simplest and most easily handled. It implies, however, that it must be feasible to lay the two cables simultaneously from the same cable ship, in order to insure their proximity to each other.

4. Preliminary tests made in May 1958 near Brest with telecommunication cables have shown that this operation is feasible, and inspection of the cables on the seabed by frogmen, using a self-propelling "submarine plane" (Fig. 9) and submarine television has shown that the cables were about 1.5 to 3 m apart (about 5 to 10 feet). It has been calculated that with the proposed current of 800 amperes, the field on the surface of the sea can thus be limited to a value such that the deviation of magnetic compasses is less than 2°.

5. The possibility of laying simultaneously two single-conductor power cables was also confirmed during recent sea trials, carried out in October 1958, at Boulogne-sur-Mer, with cables of the proposed type, that is having a copper cross-section of 340 mm² (670 MCM) and armored with 6-mm (0.236-inch) wires.

A joint was made at sea between two lengths of this cable, simulating the conditions for the making of a midchannel closing joint.

Some difficulties were experienced with flexible joints during coiling in a clockwise direction of the left-hand armored cable. New flexible joints had to be made and subsequently behaved quite well. The consequences of this difficulty, which has been encountered elsewhere,[12] are being drawn and the mechanical behavior of such submarine cable is being investigated on the basis of complementary theoretical and experimental studies.

Progress of Project. The commissioning of the direct-current interconnection is planned for the end of 1960 to secure the benefit of its advantages during the 1960-61 winter peak.

The power finally adopted, taking the possibilities of mercury vapor valves into account, is 160 mw under 200 kv, the middle point of the transmission being earthed.

The route adopted (Fig. 7) corresponds substantially to that of some of the PLUTO pipes laid during the war between Dungeness on the English coast and Le Portel on the French coast. It will be about 52-km (32-miles) long. The terminal stations, situated at a few miles from the coast, will be connected to the submarine section by land cables made to special specifications. The installations will be connected to the British 275-kv and French 225-kv a-c systems respectively.

The manufacture of rectifier equipment has been undertaken in Sweden and orders for the other equipment of the terminal stations (transformers, shunt capacitors, switchgear) will be placed shortly in both France and Great Britain.

In the light of the additional tests and studies recently completed, the final and detailed specification of the cables and joints were drawn up at the beginning of 1959, and the order for the half of the cable link to be supplied by French industry is to be placed shortly.

CONCLUSION

The comprehensive investigations related briefly in this two-part article have provided many practical results which will find their direct application to the project involved. But they may be considered to be much more far-reaching, as a result of the variety and general interest of the studies undertaken, which have led to a better understanding of many problems associated with electrical and mechanical engineering, and thus open the way to future achievements.

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New Space Environment Chamber

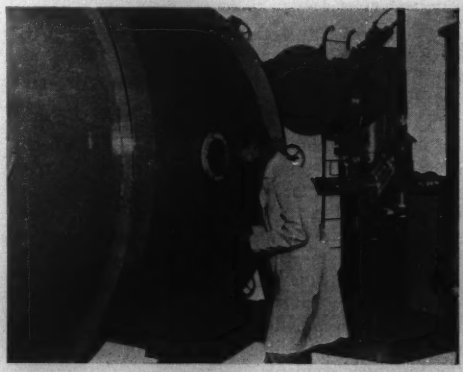
A large chamber simulating environmental conditions up to 100 miles altitude with volume sufficient to handle large equipment has been developed by Scientific Engineering Laboratories, Berkeley, Calif.

The system is track mounted to provide maximum accessibility and convenience in test preparation. The chamber can be opened either by rolling the removable end from the cylinder or by moving the cylinder from the fixed end. Equipment can be cantilevered from the fixed end, and preliminary adjustments can be made without having to work in confined quarters.

The large size of the chamber (8 feet diameter by 15 feet long) makes possible the testing of large components, subassemblies, and assemblies. Pumping equipment capacity is sufficient to handle considerable quantities of gas, such as might be experienced in combustion and ion propulsion studies.

Accessories are available for special component testing, metallurgical, biomedical, and other special projects. View, light, and feed-through ports may be quickly interchanged. Provision has been made for the addition of one or more remote vacuum monitoring stations.

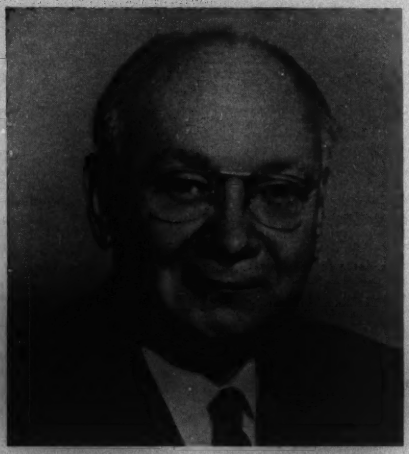
The high performance pumping system includes line-of-sight cold trapping, a 16-inch diffusion pump, backing pump, and a large mechanical pump (displacement, 485 cubic feet per minute).



Complete information on this system and other similar systems will be supplied upon request by the Scientific Engineering Laboratories.

The Institute and Its Operations

L. F. HICKERNELL
PRESIDENT AIEE



The first of three informative articles in which President Hickernell describes our present organization, internal activities, and intersociety relations. Woven throughout are historical highlights of our first 75 years.

I—Organization and Duties

THE ORGANIZATION of the Institute, while adhering to the basic form prescribed in the Rules of 1884, predecessor of our Constitution, has undergone continual change and expansion. Sometimes, these changes may seem whimsical or precipitant. This is far from the case. Each revision follows the same pattern. First, a membership need develops; second, the committee concerned, after careful study, recommends a way to meet the need; third, the Board of Directors accepts the plan and it is adopted, or rejects it, in which case the second and third steps are repeated until eventually the need is met in a manner deemed by our governing body to be in keeping with the Institute's standards.

This flexibility of the Institute may not be readily apparent at close range, but one needs only step back for a broader view, encompassing the course of AIEE history, to see clearly demonstrated a healthy ability to adapt to changing conditions.

The United States Government,[1] which has been referred to as "the largest business in the world," is composed of:

13	Departments
16	Commissions
24	Administrations
23	Government Corporations
711	Offices of . . .
96	Services
96	Bureaus
621	Divisions
46	Boards
461	Miscellaneous Bodies
2,107	Agencies

Our Institute comprises 55% as many organizational units as the Government has agencies:

1	Board of Directors
1	Executive Committee
3	Board Committees
13	District Executive Committees
112	Sections (each with Executive Committee)
72	Subsections (each with Executive Committee)
223	Section Technical Groups (each with Executive Committee)
13	District Student Activities Committees
160	Student Branches (each with Executive Committee)
5	Departments
20	General Committees
8	General Technical Committees
24	General Technical Subcommittees
6	Technical Divisions
52	Technical Committees
247	Technical Subcommittees
81	Technical Working Groups
70	Representations on ASA Sectional Committees
8	Representations on Joint Awards
29	Representations on Other Societies
1,148	Organizational Units

Except for a small Headquarters Staff, all of our operations are conducted by members. We are a "do-it-yourself" organization.

Fig. 1 shows that, for administrative purposes, our organizational units currently are grouped into:

Board of Directors and Officers
Executive Committee

Board Committees:
- Finance
- Constitution and Bylaws
- Planning and Coordination

Full text of address presented in abstract at the South East (No. 4) and South Central (No. 13) District Meeting, Atlanta, Ga., April 8-10, 1959; East Central (No. 11) District Meeting, Akron, Ohio, April 22-24, 1959; Empire (No. 1) District Meeting, Syracuse, N.Y., April 29–May 1, 1959; and Middle Eastern (No. 2) District Meeting, Baltimore, Md., May 19-21, 1959.

L. F. Hickernell is vice-president–engineering at Anaconda Wire & Cable Company, Hastings on Hudson, N. Y.

Districts:

(1) Empire	(7) South West
(2) Middle Eastern	(8) Pacific
(3) Metropolitan New York	(9) North West
	(10) Canada
(4) South East	(11) East Central
(5) Great Lakes	(12) North Eastern
(6) North Central	(13) South Central

Departments:
Administration
Admission and Advancement
Professional Development and Recognition
Publications
Technical Operations

BOARD OF DIRECTORS AND OFFICERS

A **Nominating Committee** is constituted each year consisting of one representative from each District, one from each Technical Division, and representatives from the Board of Directors not exceeding the number of Technical Divisions. It meets on the first day of the Winter General Meeting and selects a slate of Officers. Independent nominations may be submitted until March 15th. Election is conducted by ballot from April 15th to June 1st. Results are announced at the Summer Annual Meeting in June, and the new administration begins on August 1st.[2]

Institute Officers consist of a President and Treasurer elected for 1-year terms, a Vice-President from each District for a 2-year term, 12 Directors for 4-year terms, and an Executive Secretary appointed by the Board of Directors for a 1-year term.

The **Board of Directors** (until 1901 the Council) consists of the President, the two surviving Past Presidents most recently retired, the Vice-Presidents, the Directors, and the Treasurer. Its duties are to manage the affairs of the Institute. In general, it accomplishes this by establishing broad policies under which its Committees and the Districts, Sections, Branches, and Departments operate.[3] In recent years, much of its attention has been directed to reorganization, the new United Engineering Center, establishing operating policies, and intersociety affairs.

Currently, the Board holds three regular meetings each year in connection with the Fall, Winter, and Summer General Meetings.[4]

The **Executive Committee** (organized in 1896) consists of the President and Treasurer, ex officio, and five other Board members appointed by the President. It conducts the affairs of the Board between its meetings. Executive Committee meetings are called by the President.[4]

The **President** has general supervision of the affairs of the Institute, under the direction of the Board. He presides at the Board and Executive Committee meetings, and constitutionally is required to preside at "the meetings of the Institute." Because of the greatly increased number of meetings since this clause was written, in practice he presides only during the Annual Meeting, at which he is required to deliver an address. By Board Resolution,[5] his attendance at General and District Meetings and Engineers Joint Council meetings, takes precedence over visits to Sections and Branches. Except for the Nominating Committee, he appoints, and is an ex officio member of, all Standing and Special Committees. He nominates for Board appointment representatives on the governing bodies of United Engineering Trustees, Engineers Council for Professional Development, and Engineers Joint Council; and on the Boards of Award of the Hoover and Fritz Medals.

In addition to these prescribed duties, the President is called upon to represent the Institute at numerous meetings, celebrations, and other gatherings throughout America and in foreign countries. Since acceptance of all, or even most, of these invitations is impossible for one person, these representations frequently are delegated to local Officers, Members, or Honorary Secretaries. In many cases, a written message is delivered by the chosen representative.

The presidency requires the incumbent to devote

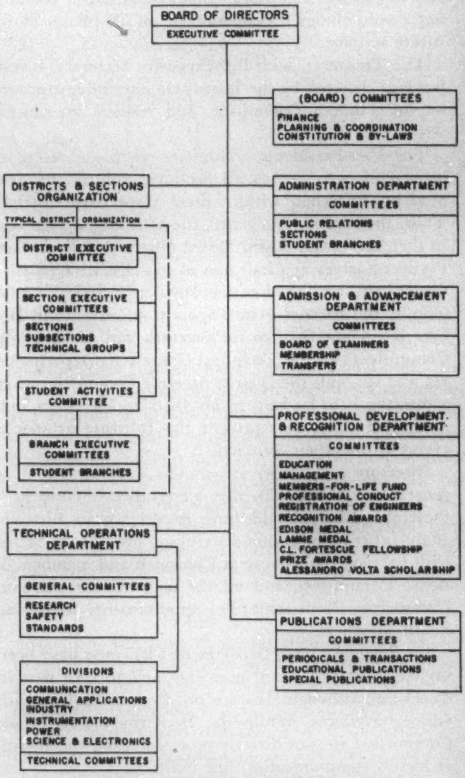


Fig. 1. AIEE Organization Chart—1958-59.

about 60% of his working hours, and all the personal time he is willing to spend, to affairs of the office.

The **Executive Secretary** is the Executive Officer of the Institute, under the direction of the President and the Board of Directors. He is designated as Secretary of the Nominating Committee, Board of Directors, and Planning and Coordination Committee. His duties are multitudinous, as evidenced by reference to his Office 37 times in the Constitution and Bylaws. Constitutionally, he is required to attend all General Meetings; in practice, he also attends District Meetings. He is in charge of the Headquarters Staff. He spends a considerable portion of his office hours in attending intersociety conferences, receiving visitors to Headquarters, consulting by phone and personally with Department and Committee Chairmen and Members, and conducting a voluminous correspondence on all phases of Institute activity.

The **Treasurer**, with the Executive Secretary, invests funds as directed by the Board. He pays bills approved by the Finance Committee, and renders an annual Treasurer's Report.

The **Vice-Presidents** administer, visit, and keep informed of activities of all Sections, Subsections, and Student Branches within their respective Districts. Thus, they are able to reflect the attitudes of members in their territories during Board discussions. Each Vice-President serves as Chairman of his District Executive Committee. He appoints the District Secretary, Chairman of the District Prize Papers Committee, and District Representatives to the Sections and Membership Committees and the Technical Operations Department. He also appoints the District Meeting Committee, when a meeting is to be held in his District. Vice-Presidents are called upon to represent the Institute at special events within their Districts.

Directors (-at-Large) are chosen without regard to geography. (Until 1921, they were called "Managers.") Preferably, they should have experience in Institute affairs other than Section activities to provide the Board with balance. They serve as Chairmen and members of Board Committees, and fill the many Committee and Intersociety Representative appointments requiring Board Members.

Since August 1956, Department Chairmen have been invited to attend Board meetings, and to take part in discussion, although they are not Board members with voting privileges. While the Departments and their Committees are not directly represented on the Board, at least a communication line exists.

BOARD COMMITTEES

The **Finance Committee** (organized in 1887) consists of three Board members, usually including the Vice-President of District 3 because of his accessibility to Headquarters. It has direct supervision of the financial affairs of the Institute. It authorizes the payment of all bills, and investment of funds with the aid of financial counsel. It renders a financial statement each year to April 30th, and recommends a budget for the ensuing fiscal year beginning May 1st for approval by the Board of Directors. It employs an accountant to audit the books at the close of each fiscal year.

Table I. Number of Sections, Subsections, and Branches By Districts, August 1, 1958

District Number	Number of: Sections A	Subsections B	Branches C	Total Units A+B+C	Visitations A+C	Total Membership
1	6	3	7	16	13	2,710
2	10	4	20	34	30	6,836
3	1	2	13	16	14	6,190
4	9	14	10	33	19	2,581
5	13	5	15	33	28	5,340
6	3	2	8	13	11	950
7	16	11	22	49	38	4,308
8	6	6	10	22	16	5,430
9	9	8	10	27	19	2,368
10	6	3	3	12	9	1,863
11	14	3	14	31	28	4,603
12	9	3	16	28	25	3,669
13	10	8	12	30	22	2,007
Total	112	72	160	344	272	48,855

The **Constitution and Bylaws Committee** (organized in 1903) consists of five members of whom at least one, usually the Chairman, is a Board member. It prepares amendments and new sections for the Constitution and Bylaws, usually after adoption "in principle" by the Board of Directors. However, it is empowered to submit its own recommendations, and consult legal and technical counsel. During the past 3 years, it has prepared an entirely revised Constitution in a more useful format which was submitted to the membership April 1, 1959. If approved, the new Constitution will take effect in August 1959.

Constitutional amendments require approval by the membership, and take effect 60 days after approval; usually at the end of August. Bylaw amendments or additions are approved by the Board of Directors and take effect August 1st, unless otherwise specified and published.

The **Planning and Coordination Committee** (organized in 1920) consists of a Board member as Chairman, the Executive Secretary, the five Department Chairmen, and members-at-large. In addition to providing coordination among Departments, it is charged with developing long-range plans and programs, and recommending means for their implementation and evaluation. It has the broadest scope of any committee in the Institute. The present departmental organization was recommended by this Committee with the aid of management consultants and membership opinion polls.

DISTRICTS

The **Districts** group into geographical territories all the Sections, Subsections, and Student Branches, and provide them with a direct line to the Board of Directors through their administrative officer, the Vice-President.

Districts were first formed in 1921, following approval by the Board of Directors in November 1920 of a plan proposed by the Special Committee on Geographical Divisions and Election Procedure. The plan grouped the membership into 10 Districts, and pro-

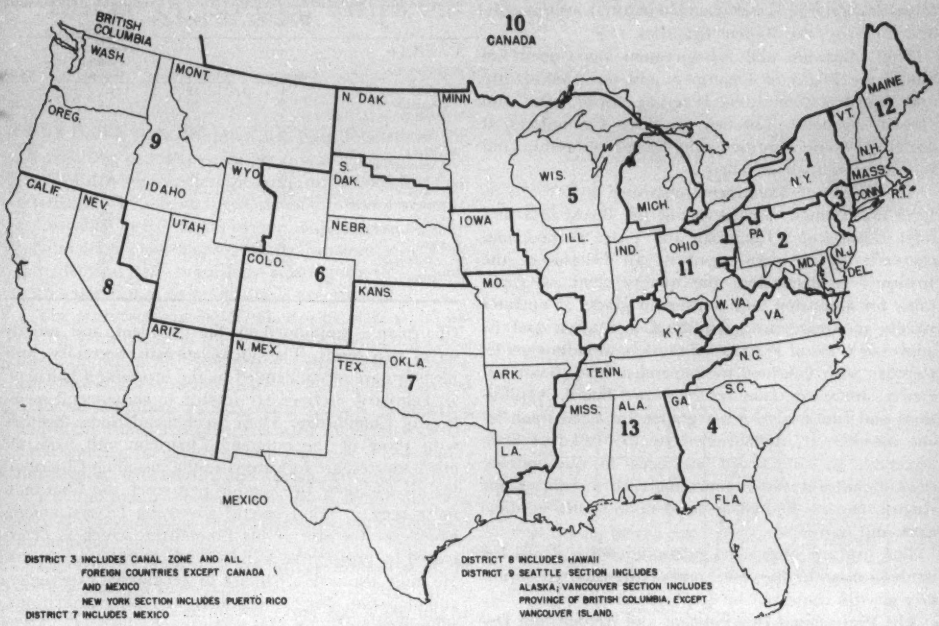


Fig. 2. Geographical Districts—1958-59.

vided for the election of a Vice-President from each District. One of the duties of the Vice-Presidents is to visit each Section and Branch in his territory every year. Records show that the desirability of visitations by officers had been recognized at least as early as 1907.

By 1952, it had become evident that some of the 10 Districts contained more Sections and Branches than a Vice-President possibly could visit annually. After several plans for redistricting were evolved and rejected by the Districts, the Board of Directors in 1955 adopted a policy permitting Districts to self-divide when, by so doing, they could better serve members within their territories. Under this form of "local option," the following divisions have taken place:

	Former District		*New Districts*	
Date	*No.*	*Name*	*No.*	*Name*
1955	2	Middle Eastern	2	Middle Eastern
			11	East Central
1957	1	North Eastern	1	Empire
			12	North Eastern
1958	4	Southern	4	South East
			13	South Central

Fig. 2 shows the present District territories.

Table I shows the number of Sections, Subsections, and Student Branches in each District as of August 1, 1958.

The **District Executive Committee** consists of the Vice-President as Chairman, the District Secretary, the Chairman and one Officer from each Section, the Chairman of the District Prize Papers Committee, the Chairman of the District Student Activities Committee, and District Representatives of the Membership and Sections Committees, and the Technical Operations Department, the Past District Vice-President (1st meeting only), and the Chairman of each Subsection (at the invitation of the Vice-President). The District Executive Committee holds one or two meetings each year, at the discretion of the Vice-President and the Committee itself.

DEPARTMENTS

In 1956, the over-all operational functions of the Institute were divided into five Departments, in which all but the three Board Committees were grouped for combined supervision.

Each **Department** consists of a Chairman, Vice-Chairman, the Chairman of its General Committees (or Technical Divisions), and members-at-large. By Bylaw and Board Resolution,[6] these Departments are charged with the supervision of their respective activities within the policies established by the Board, including the appointment of Intersociety Representatives, except for the five which are appointed by the President.

The **Administration Department** includes the Public Relations, Sections, and Student Branches Committees. It acts as a "General Staff" for the Sections and Branches. Through its three Committees, it prepares and

distributes information on Institute activities, approves formation of new Sections and territorial assignments, and supervises the Student Branches.

The **Admission and Advancement Department** includes the Board of Examiners and the Membership and Transfers Committees. It acts as central "sales" and "credit" agencies. Through its three Committees, it assists the Sections in increasing their membership, and in upgrading their members.

The **Board of Examiners** (organized in 1887 to relieve the Council, predecessor of the Board of Directors), consists of a Chairman and Vice-Chairman and currently 40 or more members, all Fellows of the Institute. It determines the qualifications of applicants for admission and transfer in grade. It operates strictly in accordance with the Constitution and its approved Code of Practice.[7] Transfers to Fellow grade, together with citations recommended by a Board reviewer, are acted upon by the entire Board. Applications and transfers to other grades are acted upon by one member, if unquestioned by the full-time Staff Secretary; by two Board members, in questionable cases. It holds an all-day meeting each month, except August. During 1957-58, it acted upon 11,016 applications and transfers.

The Institute owes deep gratitude to this Board for its dedication, loyalty, and painstaking care. Its voluntary services could not be employed at any price.

The **Professional Development and Recognition Department** includes the Education, Registration of Engineers, Professional Conduct, Management, Members-for-Life Fund, and Medals and Awards Committees. Through its 11 Committees, it develops Institute policies on content and standards of electrical engineering curricula, registration legislation, formulation and administration of a code of ethics, managerial organization and functions, disbursement of members-for-life fund, and administration of medals, awards, and prizes.

The **Publications Department** includes the Educational Publications, Periodicals and Transactions, and Special Publications Committees. Through its three Committees, it supervises the monthly journal *Electrical Engineering*, the bimonthly publications, the annual *Transactions*, and Special Publications.

The **Technical Operations Department** includes the Research, Safety, and Standards Committees; the Communication, General Applications, Industry, Instrumentation, Power, and Science and Electronics Divisions. Through its General Committees and Technical Divisions, it supervises the technical activities of the Institute, including technical programs at General Meetings; and at District Meetings, if requested. It formulates rules for presentation and discussion of papers, and handles their review by the technical committees. It schedules and conducts the Forum of Technical Committee Chairmen. Through its Representatives, it assists the Districts in establishing and guiding Section Technical Groups.

Each **Technical Committee** consists of a Chairman, Vice-Chairman, Secretary, and members-at-large. The Chairman is appointed by the President, and usually serves two terms. The Vice-Chairman, Secretary, and members are recommended by the incoming Chairman. In February, Sections are invited to recommend members of Committees. Their recommendations, together with those of the outgoing Chairman and from all other sources, are forwarded to the incoming Chairman for his selection. In choosing personnel, the Chairman must keep in mind several governing factors, among which are the size of his Committee, which is determined by prospective activity, and continuing projects. He must also seek a balance by geography, experience, and affiliation. For 1958-59, there were 288 nominations submitted by 54 (of 111) Sections, of which 147 (51%) were accepted by the Committee Chairmen.

The Technical Committees seek out and review technical papers, prepare standards, and promote activity for the subjects within their individual scopes.

Table II shows the number of organizational units in the Technical Operations Department for 1958-59.

Table II. Committee Organization—Technical Operations Department, 1958-59

	Committees	Subcommittees	Project or Working Groups	Total
Administrative	1	12	—	13
General	3	10	—	13
TOD General	3	—	—	3
Subtotal	7	22	—	29
Divisions:				
Communication	7	4	—	11
General Applications	5	30	25	60
Industry	11	47	5	63
Instrumentation	7	26	—	33
Power	11	83	32	125
Science and Electronics	9	54	19	82
Joint	1	1	—	5
Subtotal	51	245	81	379
TOTAL	58	267	81	408

CONCLUSION

Within the framework of the modern AIEE organization, any subject within the range of electrical engineering can be treated. A topic eliciting member interest can be classified into one of the Technical Divisions. Within that Division, it can be assigned to an existing Committee, or a new Committee can be established. A Subcommittee can grow into a Committee. A Committee can grow into a Division. The only limiting factor is the effort expended by members concerned with the subject.

(The second article in this series, subtitled "II—Operations and Activities," describing the work of the organizational units, will appear in the July issue of Electrical Engineering.)

REFERENCES

1. *Quote—The Weekly Digest*, Indianapolis. Ind., vol. 37, no. 7, Feb. 15, 1959, p. 6.
2. AIEE. *Organization Manual for 1958-59*, Election Procedure for Institute Officers, L. F. Hickernell, p. 160; also *Electrical Engineering*, Apr. 1955, pp. 278-80.
3. *AIEE Organization Manual for 1958-59*, Resolution adopted Oct. 5, 1956, p. 158.
4. *Ibid.*, Resolution adopted Aug. 21, 1958, p. 158.
5. *Ibid.*, Resolution adopted June 30, 1955, p. 157.
6. *Ibid.*, Resolution adopted Oct. 5, 1956, p. 158.
7. *Ibid.*, pp. 167-68.

Effect of Source Impedance on Motor Performance

ALBERT DIAMOND
ASSOCIATE MEMBER AIEE

TO DATE little attention has been focused on the resulting over-all system performance caused by the effect of driving source impedance on servomotor characteristics. The torque speed characteristics of a motor, as furnished by the manufacturer, may be correctly used for calculating the motor transfer function only when the identical test conditions relating to the driving source impedance to both phases are satisfied.

The manufacturer usually obtains his data while operating both phases of the motor from essentially a zero source impedance. Unfortunately, in the usual system application, the control phase of the motor is driven from an amplifier with a finite output impedance, and many times a capacitor is used in series with the fixed winding for phase-shifting purposes. These source impedances will modify the torque-speed characteristics of the motor, often ruining its inherent damping and, thereby, causing degeneration of the system performance.

Fig. 1 is the equivalent circuit representation of the control phase of the servomotor with a variable capacitor across the input terminals. From Fig. 1, the impedance $|Z|$ looking into terminals a-b is given as

$$|Z| = \frac{\{X_m^4 R_1^2 + X_m^2 [R_1^2 + (X_L - X_c)(X_L - X_c + X_m)]^2\}^{\frac{1}{2}}}{R_1^2 + (X_L + X_m - X_c^2)} \quad (1)$$

The numerical equivalent circuit parameters of a 400-cycle servomotor were obtained and substituted into equation 1. The resulting graph is shown in Fig. 2. From Fig. 2, it can be seen that $|Z| > R_2$ from $525 \leftarrow X_c \rightarrow 840$. Thus, the motor will run single phase for capacitive values between 0.76 and 0.48 microfarads.

The relationship between the values of capacitors which will cause a single-phasing condition and the capacitor needed for unity power factor also has to be considered. This is a prime factor since it is possible that, for any given motor, the value of capacitor needed for unit power factor will not fall inside the range of capacitor values which result in single phasing.

The approximate value of capacitance reactance necessary to resonate the control phase of a servomotor is given as:

$$X_{co} \cong \frac{X_m^2 R_2^2 (X_m + R_2)}{|X_L(R_2^2 + X_m^2) + X_m R_2| |R_2^2 + X_m^2|} \quad (2)$$

When adjustment of power factor of motor winding causes $|Z|$ to be greater than R_2, resulting in poor system response or even single phasing, corrective measures may be taken by:

1. Adding series resistance to control winding.
2. Shunting resistance across resonating capacitor.
3. Reducing output impedance of amplifier by employing negative voltage feedback around amplifier loop.

Methods 1 and 2 are both wasteful of amplifier power. Method 3 sacrifices voltage gain, usually a more reasonable compromise, inasmuch as an additional stage can be provided to re-establish the original amplifier gain.

The results of the investigation indicate that caution should be exercised when matching a motor and amplifier. Considerable sacrifices in dynamic system performance can result if the full capabilities of the servomotor are not realized because of improper driving arrangements or circuitry.

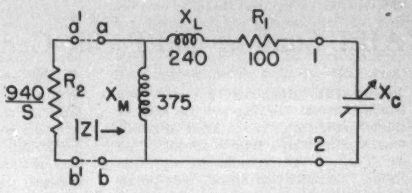


Fig. 1. Per phase equivalent circuit of a servomotor with a capacitor across the winding.

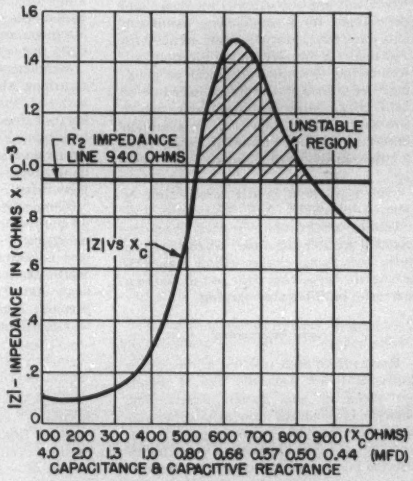


Fig. 2. Comparison of effective rotor resistance with the impedance that it sees vs capacitance across the winding.

Digest of paper 58-1028, "Effect of Driving Source Impedance on Motor Performance," recommended by the AIEE Feedback Control Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Pacific General Meeting, Sacramento, Calif., Aug 19-22, 1958. Published in AIEE *Transactions*, vol. 77, 1958 (January 1959 section).

Albert Diamond is with the United Aircraft Corp, Comack, N. Y.

INSTITUTE ACTIVITIES

Seattle Welcomes AIEE Summer and Pacific General Meeting

THE AIEE combined Summer and Pacific General Meeting will be held in the Olympic Hotel in the heart of downtown Seattle, Wash., June 21-26, 1959. The Air Transportation Conference with the theme, "Electricity in Space," will be an integral part of the meeting.

The Seattle Section extends a hearty welcome to the members of the Institute and their guests. Seattle, located on beautiful Puget Sound, is the center of the Pacific Northwest and the gateway to Alaska and the Orient. Its setting, among mountains and waterways, provides many scenic trips and makes it an outstanding vacationland. A full and diversified technical program, together with a well-rounded schedule of field trips, ladies' entertainment, social, and sports events, climaxed by a salmon barbecue, assures members and their families an interesting and pleasant meeting.

The weather in Seattle at this time of year is pleasantly cool. Warm clothing, including a light coat or sweater, is recommended for evening wear, particularly on boat trips. Sports clothes will be appropriate for the inspection trips and the salmon barbecue on Thursday evening.

Hotel Reservations

Rooms have been reserved at downtown hotels and new, centrally located motels for members and guests. Reservations should be made as soon as possible and should be received two weeks prior to the opening of the Meeting. If the hotels selected are not available, reservations will be made at a nearby hotel by the Seattle Hotel Association. Confirmation will be mailed directly to members by the Seattle Hotel Association. Every effort will be made to accommodate each request. Address requests to the AIEE Hotel Committee Chairman, D. E. Edwards, 1015 Third Ave., Seattle 4, Wash. Advance reservation cards for this purpose will be sent to all members with the mailed announcement.

The daily rates for rooms with private bath at the various hotels and motels are shown in the accompanying table.

Hotels	Blocks from Headquarters	Single	Two Persons Double Bed	Two Persons Twin Beds	Suites
Olympic Hotel (Hdqtrs.)		$8.00–$15.00	$11.00–$18.00	$14.00–$20.00	$35.00–$45.00
New Washington	6	7.00– 10.00	9.00– 12.00	10.50– 15.00	16.00– 38.00
Roosevelt	4	7.00– 9.00	10.00 12.00	12.00– 14.50	14.00– 25.00
Mayflower	4	7.00– 8.00	9.00– 10.00	11.00– 12.00	20.00
Hungerford	1	6.00– 8.00	8.00– 10.00	11.00– 12.00	
Spring Apt.	1	8.50	10.50	12.50	
Earl	1	5.00	7.00	8.00– 9.00	
Windsor	1	7.00– 9.00	9.00– 11.00	10.00– 11.00	20.00– 35.00
Camlin	6	10.00	13.00	12.00– 14.00	20.00– 25.00
Vance	7	6.50– 9.50	8.50– 11.50	11.00– 12.00	20.00
Stewart	6	6.00– 8.00	8.00– 10.00	9.00– 12.00	
Claremont	6	5.00– 7.00	6.00– 8.00	8.00– 9.00	
Exeter	3	7.00	9.00	11.00	
Motels					
City Center	12	5.50– 6.50	7.50– 8.00	8.75– 10.00	11.00– 16.00
Seattle Travelodge	9	6.50– 8.00	8.50– 10.00	9.50– 12.50	
Towne Center	7	8.78	8.78	9.82	
Towne Motel	8	8.00	9.50	10.00	

Registration

The registration desk located in the lobby of the Spanish Ballroom, Olympic Hotel, will be open at 1:00 p.m. Sunday afternoon and from 9:00 a.m. to 5:00 p.m. daily throughout the meeting.

Members should register in advance by returning the advance registration card sent with the mailed announcement. Registration fees are $5 for members and $8 for nonmembers, payable on arrival. Student members and the immediate families of members will not be charged a registration fee.

Those registering are asked to indicate on the card included with the mailed announcement the events in which they expect to participate in order to assist the Seattle Section in their plans for the various events. Tickets will not be held unless prepaid. Remaining tickets will be sold on a first-come, first-served basis.

General Session

The general session will be held Monday afternoon at 2:00 p.m. Following a welcome from the Seattle Section, Mayor Gordon Clinton of Seattle will give an address of welcome. The business meeting to follow will include reports by the officers of the Institute and introduction of officers-elect. The Lamme Medal will be presented jointly to P. L. Alger and Sterling Beckwith. Special recognition will be given the Student Prize Paper Award winners.

General Luncheon

Two general luncheons held on Tuesday and Wednesday will be of particular interest to the members. The Tuesday luncheon will provide special recognition for the 75th Anniversary of the Institute.

On Wednesday, L. A. Wood, vice-president and general manager of the Pilotless Aircraft Division of Boeing Airplane Company will address the members on "The Role and Responsibility of the Skilled Engineer in Today's Industry with Particular Reference to his Managerial and Professional Responsibility as Contrasted to his Technical Ingenuity."

Technical Sessions

A well-rounded and interesting technical program will include over 80 technical sessions featuring more than 300 papers. Sessions are scheduled at 9:00 a.m. and 2:00 p.m., from Monday through Friday, except during the general session, Monday afternoon. The Air Transportation Conference will constitute 10 of the sessions, with over 50 papers, with the theme of "Electricity in Space."

A special feature of the meeting will be an aircraft discussion panel on Wednesday evening at 7:30 p.m. The subject under discussion will be "Electrical Problems in Space," and E. C. Wells, vice-president and manager of systems management, Boeing Airplane Company, will act as moderator. Panel members will include Dr. W. H. Bostick, Stevens Institute of Technology; Dr. D. C. White, Massachusetts Institute of Technology; and Dr. R. B. Kershner, Applied Physics Laboratory, Johns Hopkins University; C. W. Burrell, Missile and Space Division, Lockheed Aircraft Corporation.

The tentative schedule of technical sessions is as follows:

Monday, June 22

9:00 a.m. Morning Sessions

Chemical Industry
Insulated Conductors
Rotating Machinery
Basic Sciences
Computing Devices and Metallic Rectifiers
Dielectrics
Research
Safety
Television and Aural Broadcasting

2:00 p.m. Annual Meeting

Tuesday, June 23

9:00 a.m. Morning Sessions

Domestic and Commercial Applications
Chemical Industry

Power Generation
Relays
Rotating Machinery
Computing Devices
Dielectrics
Section Delegates
Communication Theory and Data Communication

2:00 p.m. Afternoon Sessions

Domestic and Commerical Applications
Chemical Industry
Power Generation
Relays
Rotating Machinery
Computing Devices
Dielectrics
Section Delegates

Wednesday, June 24

9:00 a.m. Morning Sessions

Air Transportation
Air Transportation
Electric Welding
Nucleonics and Power Generation
Relays
Rotating Machinery
System Engineering
Dielectrics
Data Communciation

2:00 p.m. Afternoon Sessions

Air Transportation
Air Transportation
Electric Welding
Nucleonics
Relays and Transmission and Distribution
Rotating Machinery
System Engineering
Dielectrics
Communication Switching

7:30 p.m. Air Transportation

Thursday, June 25

9:00 a.m. Morning Sessions

Air Transportation
Air Transportation and Flight Test Instrumentation
Industrial Power Rectifiers
Transmission and Distribution
Substations
Switchgear
Dielectrics
Solid-State Devices
Radio Communication

2:00 p.m. Afternoon Sessions

Air Transportation
Industrial Power Rectifiers
Flight Test Instrumentation
Transmission and Distribution
Substations
Switchgear
Magnetic Amplifiers
Solid-State Devices
Radio Communication

Friday, June 26

9:00 a.m. Morning Sessions

Air Transportation
Air Transportation
Land Transportation
General Industry Applications
Transmission and Distribution
Substations
Magnetic Amplifiers
Transformers
Wire Communication

2:00 p.m. Afternoon Sessions

Air Transportation
Air Transportation
Land Transportation
Transmission and Distribution
Substations
Magnetic Amplifiers
Transformers
Wire Communication

Women's Auxiliary Group Meeting

A Women's Auxiliary Group meeting will be held Tuesday morning at 10:00 a.m. in the ladies' hospitality room. Delegates from all sections having women's auxiliaries or that are interested in forming auxiliaries, are invited to attend.

Social Activities

Welcome Tea—Sunday afternoon at the Olympic Hotel from 3:30 p.m. to 5:00 p.m. This popular event will provide everyone an opportunity to meet the officers of the Institute, and greet friends.

Dancing—Arrangements are being made for a no-host dance in the Olympic Hotel Tuesday evening from 9:30 p.m. to 12:00 midnight.

Theater Party—Tuesday evening at 8:00 p. m. at the Penthouse Theater. This unusual theater of the School of Drama on the University of Washington campus is the first playhouse ever designed and built for the presentation of drawing-room plays in the circus style which originated here. The theater has been reserved for AIEE members and guests that night. Tickets—$1.25 each.

Kiana Potlatch Salmon Barbecue—Thursday afternoon and evening. The highlight of the social activities for the week will be a salmon barbecue held at Kiana Lodge on nearby Bainbridge Island. Arrangements have been made in the meeting schedule so that members may leave the Olympic Hotel by bus at 4:30 p.m. to board special boats for the trip to Kiana Lodge. The boat ride includes a trip through Lake Washington Ship Canal and the Government Locks, to the salt waters of Puget Sound. A one-hour boat ride across the Sound through Agate Pass will provide a beautiful scenic trip. Complimentary refreshments will be provided during the boat trip. At the Kiana Lodge an authentic potlatch salmon barbecue will be served, followed by an interesting program. Guests will return to the hotel at 11:00 p.m. This is an ideal event for members and their families and one which will be long remembered. Tickets—adults, $10; children under 12, $5.

Sports

Sailboat Race—Wednesday afternoon. Seattle is noted as a boating center and sailboat races are held on Lake Washington throughout the summer months. The Senior Knockabout Club will hold their weekly sailboat race and arrangements have been made for a special AIEE race. Members desiring to participate will be assigned one to a boat, as crew members. Transportation will be provided leaving the Olympic Hotel at 4:30 p.m.

Salmon Fishing Trip. Salmon fishing at ocean resorts is generally good at this time of the year. Because of the distance to these fishing places, a special derby is not possible, but tentative reservations have been made for charter boats at Westport, Wash., on the Pacific Ocean, to accommodate a post-convention salmon fishing trip on Saturday. Westport is 140 miles from Seattle and fishermen will leave Seattle Friday evening, fishing early Saturday morning. Charter boat reservations are $10.40 per person. Transportation, lodging, and tackle are additional at nominal costs. In order to reserve the necessary boats, advance registration for this fishing trip must be received not later than June 15.

Golf. Arrangements at the various golf clubs will be made for those desiring to play golf, from Monday through Friday. Those wishing to play are asked to check at the sports desk.

Ladies Entertainment

The Ladies Entertainment Committee has planned a wide variety of events which will be appealing to all interests.

The ladies hospitality and headquarters room will be open daily for social gatherings and bridge. Coffee will be served from 9:00 a.m. to 10:00 a.m. daily, except Thursday, and hostesses will be present.

Seattle Chamber of Commerce

SEATTLE'S FAMED FLOATING BRIDGE—looking east to Mercer Island with Cascade Mountains in the background. Seattle will be host to the AIEE Summer and Pacific General Meeting, June 21-26, 1959, with headquarters at the Olympic Hotel.

Color Lecture and Tea—2:00 p.m. Monday afternoon, Washington Athletic Club. Helen Zundell, color analysist, who will speak on "What Is Your Personal Color Scheme?" uses models from the audience, depicting each color type, and demonstrating the individual's co-ordinated color scheme. Tickets—Complimentary.

Guided Sight-Seeing Tour and Tea—Tuesday afternoon. Busses will leave the Olympic Hotel at 1:00 p.m. The tour will provide an opportunity to see beautiful Seattle with its snow-capped mountain ranges, fresh water beaches, floating bridge, University of Washington campus, and several outstanding residential areas. They will be served tea at the Seattle Art Museum where the finest 17th and 18th Century jade collection in the world, and renown Cress collection of old masterpieces can be seen. Tickets—$3.

Fashion Luncheon and Fashion Commentary—Wednesday noon at the Seattle Tennis Club. Buses will leave the Olympic Hotel at 12:00 noon. Bernice Caverly of Frederick and Nelson, Seattle's outstanding department store, will speak on "Advance Report of Fall Fashion, Designers and European Boutiques." Tickets—$4.

Brunch and Flower Arrangement Demonstration—10:00 a.m., Thursday morning, Olympic Hotel. Crissey, one of Seattle's leading florists and outstanding in the flower arrangement field, will present a flower arrangement demonstration. Tickets—$3.

Inspection Trips

A program of inspection trips of both general and technical interest featuring Pacific Northwest Industries has been arranged. Since the number of persons who may be accommodated on some of these trips is limited, members are urged to secure advance registrations as soon as possible. Advance registrations should be made on cards mailed to the members for this purpose. The inspection trips scheduled are as follows.

Aerial Cruise, Hydroelectric Plants—Wednesday afternoon. Hydroelectric plants provide the prime energy source for Pacific Northwest utilities and many interesting projects are located throughout Washington. To provide a bird's eye view of some of these plants, a plane trip lasting approximately 5 hours will fly to and circle major plants, including Puget Sound Power & Light Company Baker River project; City of Seattle Skagit River project; and the Grand Coulee, Chief Joseph, Rock Island, and Rocky Reach Dams on the Columbia River. Bus leaves the Olympic Hotel at 12:30 p.m. The fare includes bus and plane trip. Regisrtation should be made in advance. In case the weather is bad and the trip cancelled, money will be refunded. Ticket—$27.50 each.

Skagit Hydroelectric Project, City of Seattle—All day Wednesday or Friday. The City of Seattle's main power development on the Skagit River in scenic Mount Baker National Forest, 140 miles from Seattle, consists of three major dams—Gorge, Diablo, and Ross. Located deep in the Cascade Mountains, the visitor has an excellent opportunity to view Washington mountain scenery at its finest. The trip includes a one-hour boat ride, a ride on an incline railway, inspection of the powerhouses, and lunch and dinner at the site. Buses leave the Olympic Hotel at 6:45 a.m. This is a splendid family trip. Advance registration should be made to assure reservations. Ticket price, including meals—$9.

Puget Sound Naval Shipyard, Bremerton—Tuesday afternoon. This includes a pleasant one-hour ferry trip across Puget Sound, and a tour of the Naval shipyard. The visitors will board the famous battleship *USS Missouri* and the aircraft carrier *USS Coral Sea*, currently being converted to an angle deck carrier. Missile cruisers and destroyers are under construction and a large new drydock for the Forrestal class carriers is being started. The ferry will leave the Colman Dock in Seattle at 1:00 p.m. Ferry fare, to be paid on an individual basis, is $1.50; no other charges.

White River Lumber Mill and Tree Farm, Weyerhaeuser Timber Company—All day Friday. The trip involves a 60-mile bus trip to a modern forestry and milling operation. Visitors will watch the making of timber products from the felling of giant firs to final manufacture in a modern mill. It includes logging operations, hydraulic barking, a residue burning power plant, and a scientifically managed tree farm which will sustain a continuous supply of logs for the mill. The bus will leave the Olympic Hotel at 8:30 a.m. The cost of the trip includes a box lunch served in the woods. Ticket—$4.50.

Scott Paper Mill, Everett—Wednesday afternoon. This trip involves a 30-mile bus trip to a large bleached sulphite pulp mill. It is one of the largest plants in the manufacture of paper tissue in the United States. The visitors will see the entire process of converting logs into all types of paper products. Buses will leave the Olympic Hotel at 4:30 p.m. Ticket—$2.50. Dinner in the mill cafeteria—$1.25.

Boeing Airplane Company, Seattle Plant No. 2—Tuesday morning. This plant contains the largest single-owned private aerodynamics laboratory, including wind tunnels where models of advanced types of aircraft and missiles are tested. One of the tunnels is transonic and the other is supersonic with a potential up to Mach 3. A third tunnel for speeds up to 18,000 mph is under development. The buses leave the Olympic Hotel at 9:30 a.m. Ticket—$1.25.

Boeing Airplane Company, Renton Plant—Friday afternoon. This plant produces the *KC 135* jet tankers for the Air

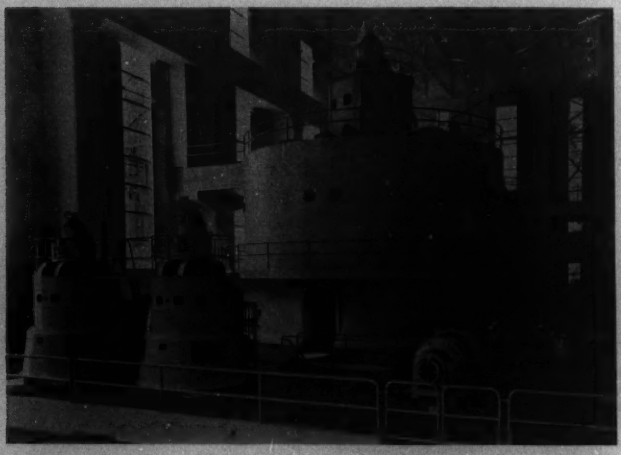
Annual Meeting

The Annual Meeting of the American Institute of Electrical Engineers will be held in Seattle, Wash., at 2:00 p. m., Monday, June 22, 1959, during the Summer and Pacific General Meeting.

At this meeting, the annual report of the Board of Directors and the reports of the Committee of Tellers on the ballots cast for the election of officers and for the proposed amendments to the AIEE Constitution will be presented. The Lamme Medal will be presented to Philip L. Alger (AM '17, M '22, F '30) and Sterling Beckwith (AM '34, M '42, F '49).

Such other business, if any, as may properly come before the Annual Meeting may be considered.

Signed N. S. HIBSHMAN
Executive Secretary



INTERIOR VIEW OF DIABLO POWERHOUSE, middle one of Seattle City Light's three Skagit River plants. The two large generators each have a capacity of 64,500 kw; the two house units in the foreground are each rated at 1,500 kw, making the total capability of the plant 132,000 kw. New turbine runners and other modernization changes being made this year are expected to increase the plant capability by 29,000 kw.

Force and the 707 jet transports for commercial airlines, which have a speed of 600 mph. The visitors will observe the production of these giants of the air on the assembly line. The buses leave the Olympic Hotel at 1:30 p.m. Ticket will be $1.75.

Pacific Telephone & Telegraph Company, Telephone Building—Monday and Wednesday afternoon and evening. This is a modern building with window areas kept to a minimum for defense reasons. It includes No. 5 crossbar equipment handling both local and long distance dialing. The tour will include a lecture-demonstration of direct distance dialing. Departure from the Olympic Hotel will be at 2:00 p.m. and 7:30 p.m. There will be no charge.

Other Trips, Special Arrangement. Other trips will be available for those interested. These include a 30-mile bus trip to the hydroelectric plant of the Puget Sound Power & Light Company at Snoqualmie Falls. This is one of the oldest underground plants in the world, where the generators, originally installed in 1898, are located in the bottom of a man-made rock cavity reached by an elevator. Another trip is to the Alder and LaGrande hydroelectric plants of the City of Tacoma on the Nisqually River, involving a 60-mile bus trip.

Hawaii Tour

An all-expense tour leaves the Seattle-Tacoma airport at 11:15 p.m., Friday, June 26, and returns July 5. Included in the tour is round trip transportation via Pan American Airways from Seattle to Honolulu and return to Los Angeles, San Francisco, Portland, or Seattle. Also included is air transportation on an outer island trip, sightseeing, hotel room, meals, and ground transportation. Address all correspondence to Bankers and Merchants Travel Service, 511 5th Ave., New York 17, N. Y. The total cost is $487, plus $8.73 tax per person. A deposit of $50 should accompany the reservation application.

Committee

The General Meeting committee includes: H. R. Loew, chairman; H. R. Brown, vice-chairman; C. S. Alger, secretary; H. V. Strandberg, treasurer; J. D. Eicher, finance; F. R. Bergseth, program; D. E. Edwards, hotel; R. L. Lemman, entertainment; T. J. Martin, properties; F. D. Robbins, student activities; R. E. Kistler, publicity; J. V. Lamson, registration; R. L. Simmonds, sports; C. D. Jorgensen, transportation; C. R. Kingsbury, trips; Mrs. C. S. Alger, ladies program; D. W. Exner, Air Transportation Program.

Atlanta Is Host to Joint District Meeting of AIEE

ATLANTA, GA., was host to the AIEE Joint District Meeting of the South East District No. 4 and South Central District No. 13, April 8-10, 1959, held at the Dinkler Plaza Hotel. Attendance exceeded 550 members, wives, and guests. There were approximately 66 papers read at 17 technical lessons. Students were liberally represented.

A group of interesting inspection trips to leading local industries had been arranged in advance of the meeting by the program committee. Visits were made to: Carling Brewing Co.; Georgia Power Company's 230-kv Morrow Substation; Lockheed Aircraft Corporation; Owens-Illinois-Glass Container Division; Ford Motor Company Assembly Plant; Georgia Institute of Technology Computer Center; Southern Railway Company's Inman Yards; the local telephone company; and the Atlanta Steel Company, which has one of the most modern steel rolling mills in the world.

General Session

The general session was opened by R. G. Elliott, vice-president, Southern Bell Telephone & Telegraph Co., and general chairman of the Joint District Meeting. His Honor W. B. Hartsfield, mayor of Atlanta, followed with an address of welcome to the assembled delegates.

AIEE President L. F. Hickernell, who followed the Mayor, spoke on the "Institute and Its Operations." Using an organizational chart which had been distributed to the delegates, he briefly explained the functions of the various committees and departments, stressing the broad membership base on which their activities rest. He noted that "the United States Government, which has been termed the largest business in the world, is composed of 2,100 separate agencies. To give you some idea of the complexity of our Institute, we have 55% as many organizational units as the Government has agencies. And except for a small headquarters staff, all of our operations are conducted by members. We are a 'do-it-yourself organization'." Part I of the full text of this address appears on page 672 of this issue. Parts II and III will appear in subsequent issues of *Electrical Engineering*.

At the conclusion of his speech, President Hickernell presented a plaque to H. W. Oetinger, Duke Power Company, in honor of his last two years of distinguished service as vice-president of District No. 4.

Dr. E. D. Harrison, president, Georgia Institute of Technology, was the principal speaker. He spoke on the theme of the Joint District meeting, "Industry Is Humming DIXIE."

Student Prizes

Two Alabama and Duke University electrical engineering students were awarded first prizes for student technical papers presented before the AIEE meeting. Three prizes were awarded, in each of two AIEE Districts comprising nine southern states.

Recipients of first prize awards were: for District No. 13, W. W. Clements, University of Alabama for his paper, "A Short-Range One-Way Communication System"; and for District No. 4, W. E. Montgomery, Duke University, for his paper "Design and Construction of a Solid-State Video Pickup." The prize includes a $25 cash award, and a paid trip to the Summer and Pacific General Meeting of AIEE in Seattle, Wash., in June, where these two winners will compete with the other District winners.

Second place winners were: T. F. McIntosh, North Carolina State College, "Wide Signal Discriminator for Pulse Selection

STUDENT prize paper winners *(left)* from District No. 4: *(left to right)*, Neil Lesser, T. F. McIntosh, and W. E. Montgomery, with Prof. E. R. Weston, counselor, Georgia Institute of Technology Student branch. *Right:* Student prize paper winners from District No. 13 *(left to right)* J. L. Grisson, E. M. Stokely, and W. W. Clements, with Prof. W. F. Gray, counselor, University of Alabama Student Branch.

AIEE OFFICIALS *at the South East and South Central Joint District Meeting in Atlanta, Ga., April 8-10, 1959, are: (left to right)* **J. W. Davis, vice-chairman of the meeting; H. W. Oetinger, vice-president, District No. 4; and C. J. Grimm, chairman of the AIEE Student Branches Committee.**

in Missile Guidance Systems; and a tie between E. M. Stokely, Mississippi State University, "Reactance Amplifiers," and J. L. Grisson, Tennessee Polytechnic Institute, "A Different Approach to the Problem of Automobile Ignition."

Third place winner was: Neil Lesser, Georgia Institute of Technology, "An Alpha-Numeric Punched-Card Reader."

Second and third prizes, presented by the Members-for-Life Fund are: $25 for second place, and $15 for third place. The fund also provides the expenses for the trip to the Summer and Pacific General Meeting.

Technical Sessions

Power Generation. The Georgia Power Company's Oliver Dam hydroelectric station, scheduled to begin operation in June 1959, was described in a paper "Olive Dam Hydro Plant Design," by R. J. Kelly, of the Georgia Power Company. The dam, which is located on the Chattahoochee River at the north city limits of Columbus, Ga., has an installed generating capacity of 60,000 kw, with an annual generation of 255 million kw-hr. The generating facilities are of the unit type construction and the plant is designed for completely automatic, remotely controlled operation. Oliver Dam, a so-called "run of the river" plant, will be integrated with existing dams at Bartletts Ferry and Goat Rock River upstream and the North Highlands down river. The dam is of concrete with a spillway 1,324 feet long. It contains 33 radial gates, nonoverflow sections approximately 499 feet long, and an intake section 198 feet long. The dam is approximately 80 feet high above the river bed at the headworks. The powerhouse has two floors, a generator room at an elevation of 286 feet and an outdoor deck over the generating floor at an elevation of 299 feet. The installed capacity of the powerhouse will be 84,700 hp from 3 turbines of 25,400 hp and one of 8,500 hp.

Other papers were "The Use of D-C Overpotential Testing as a Maintenance Tool in the Industrial Plant," W. A. Weldendorf, Mutual Boiler and Machinery Ins. Co.; and "Switchgear Insulation," N. Kreekon, Allis-Chalmers Manufacturing Company.

Atomic Power in the Southeast. Problems besetting construction of a nuclear powered aircraft are either being solved or logical programs are being implemented to develop details of the solutions, C. W. Holland, Lockheed Aircraft Corporation engineer, reported in his paper "Electrical Engineering in Atomic Powered Aircraft." Through the concerted efforts of the U. S. Air Force and the aviation industry, the author readily envisions the day when nuclear powered aircraft will be as concrete achievements as are the generating stations and the submarines of today. The author pointed out that although the solution to many problems involved are classified, one should not draw the inference that we are a long way from practical realization of the application of nuclear power plants to airplanes. He stated that the vast majority of the problem areas have been resolved and straightforward practical methods leading to the solution of such open items as do exist have been formulated. Mr. Holland then outlined the problems posed by the weight of a reactor, radiation effects on electrical components and the aircraft itself, on the crew as well as the repair crews, inspectors, and others who would be charged with repair and inspection of nuclear aircraft.

In a companion paper, W. B. Harrison, Georgia Institute of Technology, discussed changes and extensions in the traditional boundaries of many educational fields to keep up with the projected growth of nuclear power and with the extended use of radiation in many fields of endeavor.

A paper by Capt. P. K. Taylor, USN, discussed the revolutionary import in submarine development brought about by nuclear power.

Continuing Education for Engineers. Approximately 800 of the 1,500 engineers employed by the Southern Bell Telephone and Telegraph Company in nine states have attended company-sponsored courses in the company's "Centralized Engineering Training Program," W. L. Sullivan, Southern Bell engineer reported in his paper "Engineering Training in an Operating Telephone Company." He said that in this group there were 186 engineers who had attended two courses, 74 three courses, 31 four courses, and 10 five courses of instruction. The author pointed out that continuing education of engineers has proved to be necessary for four reasons: first, for purposes of specialization; second, for periodic review of some of the fundamentals of engineering science; third, for keeping abreast of the advancement in the art; and fourth, for broadening the engineer's viewpoint beyond his immediate work. Courses are offered in fundamental engineering, equipment engineering, air conditioning engineering, microwave engineering, and plant extensions engineering.

A companion paper was the "Georgia Power Co. Nuclear Reactor Engineering Course," by H. H. Strozier, Georgia Power Co.

Instrumentation. An improved troubleshooting technique to detect aircraft subsystem malfunction under dynamic environmental conditions encountered during flight was described by John Jamgochian and T. K. Speer of the Lockheed Aircraft Corp., Marietta, Ga., in their paper "In Flight Recordings Test of Systems." The technique measures all of the key system parameters simultaneously so that the functional operation of all the portions of a system can be observed as the input parameters are varied. Although the primary object was the recording of data in flight, the system was successfully employed as a ground test set for preflight testing. The application of this system has been highly successful, the authors reported, but pointed out that errors in analysis of recorded data have occurred. These errors normally were created, not because the data was not available, but because the record analyst failed to observe vital information and attach the proper significance to signal variations.

Other papers were "The Electrical Engineer in Chemical Process Instrumentation," G. Alford, Chemstrand Corp.; "Instrumentation and Process Control," W. R. Mickelson, General Electric Co.; "Instrumentation in the Paper Industry," K. A. Riddle, Rome Kraft Paper Company.

Automatic Load and Frequency Control. Modern devices in the form of an automatic dispatching system that is capable of computing, directing and controlling the generators in an electric utility can effect lucrative savings in system operating costs. The general nature of such systems was described by M. J. Brown and R. L. Tremaine, both of Westinghouse Electric Corporation, East Pittsburgh, Pa. Automatic dispatching equipment is applied,

they said, in an area where high reliability is very important. Factors affecting reliability must be carefully evaluated. These are: component selection, arrangement of parts, circuits employed, provisions for operation under abnormal conditions, means of testing, and maintenance. Cost and complexity are not simply related to reliability. High-cost, low-production items may be most reliable in some cases; low-cost, high-production items may be most reliable in other cases. The authors noted that unitized equipment made up of modular units or building blocks provide an arrangement that enhances reliability in that partial operation, quick inspection, and maintenance are possible. Reliability measurements can be readily kept and such measurements as have already been reported show a very acceptable service factor for modern dispatching tools.

Companion paper was "Some Qualitative Considerations for Supplementary Generation Controllers on Units of an Interconnected System with Multiple Control Areas," W. S. Bloor, Leeds and Northrup.

U. S. Computer Technology Leads in Program for Global Computer Conference

THE VERY STRONG world-wide position of United States computer technology has been confirmed in the final program plans for the forthcoming global computer conference sponsored by an organization of the United Nations in Paris, France, June 13-23, 1959. The formal technical program alone will feature 23 of 55 papers from United States computer experts.

More than 2,500 scientists, engineers, and mathematicians meeting in San Francisco, Calif., for the Western Joint Computer Conference heard the first official details of the program recently finalized in Paris by consultants to UNESCO (United Nations Educational, Cultural and Scientific Organization) from the 13 participating nations. It also was the first public announcement of the high honors accorded to certain leading computer specialists from the United States in appointing them to official positions for the global event.

A special new session had been added to the formal program which will explore "Computer Techniques of the Future." It was also disclosed that United States manufacturers of computer and data-control systems would have considerable exhibit space in AUTO-MATH 59, a major equipment exhibit held in conjunction with the Conference. More than 600 Americans have made known their intention to attend the Conference and exhibit.

The progress report to the Western Joint Computer Conference was made at a luncheon on March 4 at the Fairmont Hotel by Evan Herbert, of the United States Committee for the International Conference on Information Processing (USICIP). This Committee is sponsored by the AIEE, the Institute of Radio Engineers (IRE), and The Association for Computing Machinery (ACM), the three societies that sponsored the Western Joint Computer Conference. Mr. Herbert relayed the report of the Paris activities of the U. S. Consultant to UNESCO, I. L. Auerbach, who is also chairman of USICIP.

The report noted, with considerable pride, that the position of Honorary Chairman of the International Conference had been accorded to Prof. Howard Aiken, of Harvard University Computation Laboratory. Dr. Aiken is known both nationally and internationally as one of the earliest pioneers in computers. He was one of the original developers of the Harvard Mark I computer, the first large-scale integrated digital computer. Another famed United States personage in the computer world was named one of the Honorary Vice-Chairmen of the Conference. He is Dr. J. W. Mauchly, of Sperry Rand Corporation, a co-developer of UNIVAC. Other vice-chairmen were named from Japan, USSR, France, Italy, Spain, United Kingdom, Netherlands, and the German Federal Republic.

Dr. Saul Gorn, of the University of Pennsylvania, has been named rapporteur for the sessions of Common Symbolic Language for Digital Computers. The post of rapporteur in a global computer conference is a particularly high honor. A rapporteur is charged with the responsibility of giving the background for the session, bringing to an already sophisticated audience a perspective on the state of the art in a chosen area. He is, in a technological world, equivalent to the person who delivered the prologue in a Greek drama—verbally setting the stage for the assembled audience.

I. L. Auerbach, president of Auerbach Electronics Corporation, Narberth, Pa., was appointed president of the new session on Computer Techniques of the Future. Vice-President is A. Speiser, of Switzerland. Mr. Auerbach will organize the session. It will contain about six papers with one German paper on parametrons already accepted and others expected from England, USSR, and the United States. Subject matter is expected to cover cryogenics, thin films, multiaperture devices, and other new techniques now emerging from the research laboratories.

The balance of the sessions have now had finalized programs, with computer experts from the United States represented on the program in all of the major areas covered by the Conference: Methods of Digital Computing, Logical Design of Digital Computers, Common Symbolic Languages for Computers, Automatic Translation of Languages, and Pattern Recognition and Machine Learning. In the logical design area, Dr. Alston Householder of the United States has been appointed to the presidency of a session on High-Speed Computation. Dr. Householder is with Oak Ridge National Laboratories and is also program chairman of USICIP. He is well known in international computer circles and was formerly the president of ACM.

Other computer personages from the United States who have been honored with official positions on the Conference program are Dr. Grace Hopper and Dr. S. N. Alexander. Dr. Hopper has been appointed vice-president of the sessions on Common Symbolic Language for Digital Computers, a field in which she is already known in conjunction with her activities at Sperry Rand's Remington Rand UNIVAC Division.

Similarly, Dr. Alexander has been appointed vice-president of the session on Proving Theorems, which is included in the conference area on Pattern Recognition and Machine Learning. Dr. Alexander is chief of the Data Processing Division of the National Bureau of Standards. He is also a member of USICIP .

With 13 major symposia now included in the program, it is particularly significant that the United States computer people will act as co-ordinators of six of these. A

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large number of Americans have indicated to USICIP that they will take active part in all 13 symposia.

AUTO-MATH 59, the computer and data control equipment exhibit, which will overlap the Conference from June 13 to 23, will be the scene of much American activity. Major American companies will be exhibiting directly and through foreign subsidiaries. Six papers on new equipment developments in the United States have been provisionally accepted by UNESCO consultants for presentation during AUTO-MATH 59 technical sessions: "The Burroughs *220* High-Speed Printer System," Burroughs Corp., ElectroData Div.; "Two New High-Speed Electronic Digital Computer Readout Systems—*S-C 5000* High-Speed Electronic Printer, *S-C 4020* High-Speed Electronic Microfilm Printer," General Dynamics Corp., Stromberg-Carlson Div.; "Magnacard—Storage of Information on Magnetic Cards," "Magnavox Company; "Advanced *RW-300* Computer Systems," Thompson Ramo Wooldridge; "The Source Document Processing Center," Telemeter Magnetics; "Royal Precision Data Processing Systems," Librascope.

United States firms exhibiting at AUTO-MATH 59, directly or through their foreign subsidiaries, include: IBM-France, Royal McBee through Mecanalyse, Benson Lehner Corporation, Burroughs Corporation, Teleregister Corporation, Friden, Telemeter Magnetics, Ampex Corporation, and Minnesota Mining and Manufacturing Corporation.

To transport the large United States contingent to Paris for the Conference. USICIP has concluded arrangements with three major airlines. Using data-processing equipment to handle the original travel registrations of United States computer experts, the Committee is funnelling transportation requirements into already blocked off USICIP flights on KLM Royal Dutch Airlines from New York and SAS (Scandinavian Airlines System) from Los Angeles over the Polar Route. Special interconnecting flights for the USICIP international flights have been arranged with American Airlines, the official domestic carrier. Among the interconnecting flights, *707* Jet Flagships will connect the international gateways on both coasts.

Tentative Program

Plenary Sessions

The formal technical program covering five subject areas will be presented in ten 3-hour plenary sessions in the new UNESCO House June 15 through June 20. A general rapporteur will present an introductory discussion on each of the five subjects. There will be simultaneous oral translation of the technical papers into English, French, Russian, and German. Comments from the floor will be invited, and the published Conference Proceedings will contain the entire text of the papers and the discussion from the floor, provided the latter is also submitted in writing. All abstracts and preprints will be provided to officially registered Conference participants prior to the Conference.

Honorary Chairman: Prof. H. H. Aiken (U.S.)

Honorary Vice-Chairmen: M. Goto (Japan), S. A. Lebedev (USSR), J. W. Mauchly (U.S.), M. Peri (France), M. Picone (Italy), G. Santesmases (Spain), M. V. Wilkes (United Kingdom), A. van Wijngaarden (Netherlands), K. Zuse (German Federal Republic)

1. Methods of Digital Computing

Rapporteur: J. Kuntzmann (France)

Errors Approximations

President: E. de Possel (France)

Vice-President: L. Amerio (Italy)

Rounding Errors in Algebraic Processes. *J. H. Wilkinson* (UK)

Sur l'Estimation des Erreurs d'Arrondi. *C. Blanc* (Switzerland)

Theoretical and Experimental Studies on the Accumulation of Error in the Numerical Solution of Initial Value Problems for Systems of Ordinary Differential Equations. *P. Henrici* (U.S.)

Rational Approximations for Transcendental Functions. *H. J. Maehly* (U.S.)

The Exact Determination of the Characteristic Polynomial of a Matrix. *D. B. Gillies* (U.S.)

Partial Differential Equations, Applications, and Linear Programming

President: A. Ghizzetti (Italy)

Vice-President: J. Carteron (France)

The Use of High-Speed Digital Computers for the Solution of Partial Differential Equations. *A. A. Dorodnitzin* (USSR)

Methods of Computation on Digital Computers for Partial Differential Equations. *L. Collatz* (Germany)

The Solution of Elliptic Difference Equations by Stationary Iterative Processes. *D. J. Evans* (UK)

Overrelaxation Applied to Implicit Alternating Direction Methods. *R. S. Varga* (U.S.)

Resolution sur Calculateur Electronique d'un Probleme d'Algebre Diophantienne. *G. Letellier, R. Laties* (France)

Les Programmes Logarithmiques—Application aux Calculs des Programmes Convexes Specialement Lineaires. *G. R. Parisot* (France)

2. Logical Design of Digital Computers

Rapporteur: M. V. Wilkes (UK)

Logical Design in General

President: H. Yamashita (Japan)

Vice-President: Stiefel (Germany)

(Continued on p. 686)

AIEE Past President Honored by Japanese Engineering Society

R. W. SORENSEN, past president (1940) and honorary member of the AIEE, was honored at a tea party given by The Institute of Electrical Engineers of Japan (IEEJ) during his recent visit to that country. Dr. Sorensen is an honorary member of the Japanese Society. Among those present at the luncheon were *(clockwise, from bottom left)*: **Yotsuo Toriyama, Musashi Technical University; Kiyoshi Ishikawa, local honorary secretary of AIEE, past president of IEEJ, managing director of Nippon Genshiryoku Jigyo Co.; Teiji Momota, past president of IEEJ, auditor, Tokai Denkyoku Seizo Manufacturing Co.; Daigoro Yasukawa, president of Nippon Genshiryoku Hatsuden Co.; Tamaki Ipponmatsu, president of the IEEJ, vice-president, Nippon Genshiryoku Hatsuden Co.; Masato Hirano, Nippon Genshiryoku Hatsuden Co.; Junji Tomiyama, vice-president of IEEJ, Central Research Institute of Electric Power Industry; Sakuji Komagata, past president of IEEJ, chief manager of Nippon Genshiryoku Kenkyusho; Gohei Monna, Nippon Sanso Co.; K. Hisada; Y. Kugano; N. Tano; Ichiro Hano, accounting director of IEEJ, Waseda University; Hirosaburo Yamamoto, investigating director of IEEJ, manager, research department, Fuji Electric Manufacturing Co.; Tamotsu Hiyama, Columbia Record Co.; Kanejiro Takahashi, board member, Sasaki Wire Co.; Matsujiro Oyama, past president of IEEJ, director of Central Research Institute of Electric Power Industry; Dr. Sorensen; Yasujiro Niwa, past president of IEEJ, chairman of Liason Committee of IEEJ, president, Tokyo Electric University; Yoshichiro Shimizu, president, Nippon Television Broadcasting Network Co.; Shuhei Fujitaka, general affairs director of IEEJ, Institute of Industrial Science Tokyo University; Yasujiro Shimazu, director, Nippon Electric Co.**

AIEE Future Meetings

International Conference on Information Processing
UNESCO House
Paris, France
June 15-20, 1959
(Exhibits June 13-22)

Paper and Pulp Conference*
University of Maine
Orono, Maine
June 18-19, 1959

Summer and Pacific General Meeting*
Olympic Hotel
Seattle, Wash.
June 21-26, 1959

Air Transportation Conference*
(at Summer General Meeting)
Olympic Hotel
Seattle, Wash.
June 22-26, 1959

Petroleum Industry Conference
Wilton Hotel
Long Beach, Calif.
August 23-26, 1959
(Final date for †TP—closed, ‡CP Syn.—June 9, CPMs—June 19)

AIEE-ASME Engineering Management Conference
Statler Hotel
Los Angeles, Calif.
September 16-18, 1959
(Final date for †TP—June 18, ‡CP Syn.—July 3, CPMs—June 13)

AIEE-IRE Nonlinear Magnetics and Magnetic Amplifiers Conference
Shoreham Hotel
Washington, D. C.
September 23-25, 1959
(Final date for †TP—June 22, ‡CP Syn.—July 10, CPMs—July 20)

AIEE-ASME National Power Conference
Muehlebach Hotel
Kansas City, Mo.
September 27-October 1, 1959
(Final date for †TP—June 29, ‡CP Syn.—July 14, CPMs—July 24)

AIEE-IRE Industrial Electronics Conference
Melon Institute
Pittsburgh, Pa.
September 30-October 1, 1959
(Final date for †TP—July 2, ‡CP Syn.—July 17, CPMs—July 27)

Fall General Meeting
Morrison Hotel
Chicago, Ill.
October 11-16, 1959
(Final date for †TP—June 12, ‡CP Syn.—July 30, CPMs—Aug. 7)

National Electronics Conference
Sherman Hotel
Chicago, Ill.
October 12-14, 1959
(Final date for †TP—July 14, ‡CP Syn.—July 28, CPMs—Aug. 7)

Fall Textile Conference
Charlotte Hotel
Charlotte, N. C.
October 15-16, 1959
(Final date for †TP—July 17, ‡CP Syn.—July 31, CPMs—Aug. 11)

Machine Tools Conference
Hotel Cleveland
Cleveland, Ohio
October 19-21, 1959
(Final date for †TP—July 21, ‡CP Syn.—Aug. 4, CPMs—Aug. 14)

AIEE-IRE-ISA National Automatic Control Conference
Sheraton Hotel
Dallas, Tex.
November 4-6, 1959
(Final date for summaries—June 1)

AIEE-IRE-ISA Electrical Techniques in Medicine and Biology Conference
Sheraton Hotel
Philadelphia, Pa.
November 10-12, 1959
(Final date for †TP— Aug. 12, ‡CP Syn.—Aug. 28, CPMs—Sept. 7)

Magnetism and Magnetic Materials Conference
Sheraton Cadillac Hotel
Detroit, Mich.
November 16-19, 1959
(Final date for †TP—Aug. 18, ‡CP Syn.—Sept. 1, CPMs—Sept. 11)

AIEE-IRE-ACM Eastern Joint Computer Conference
Statler Hotel
Boston, Mass.
November 30-December 3, 1959
(Final date for †TP—Sept. 1, ‡CP Syn.—Sept. 15, CPMs—Sept. 25)

AIEE-NEMA Second National Conference on Application of Electrical Insulation
Shoreham Hotel
Washington, D. C.
December 8-10, 1959
(Final date for †TP—Sept. 9, ‡CP Syn.—Sept. 25, CPMs—October 5)

AIEE-IRE-ASQC Symposium on Reliability and Quality Control
Hotel Statler
Washington, D. C.
January 11-13, 1960
(Abstracts—June 15, final papers—Oct. 15)

Winter General Meeting
Hotel Statler
New York, N. Y.
January 31-February 5, 1960
(Final date for †TP—Nov. 2, ‡CP Syn.—Nov. 17, CPMs—Nov. 27)

AIEE-IRE-U of P Transistor and Solid-State Circuits Conference
University of Pennsylvania
Philadelphia, Pa.
February 11-12, 1960
(Final date for †TP—Nov. 12, CP Syn.—Nov. 27, CPMs—Dec. 8)

EJC Nuclear Congress
New York, N. Y.
April 3-8, 1960

Southwest District Meeting
Shamrock-Hilton Hotel
Houston, Tex.
April 4-6, 1960
(Final date for †TP—Jan. 4, DPMs—Jan. 29)

East Central District Meeting
Daniel Boone Hotel
Charleston, W. Va.
April 12-14, 1960
(Final date for †TP—Jan. 13, DPMs—Feb. 5)

AIEE-ASME-IRE Automatic Techniques Conference
Cleveland, Ohio
April 18-20, 1960
(Final date for †TP—Jan. 19, ‡CP Syn.—Feb. 2, CPMs—Feb. 12)

Great Lakes District Meeting
Hotel Pfister
Milwaukee, Wis.
April 27-29, 1960
(Final date for †TP—Jan. 28, DPMs—Feb. 22)

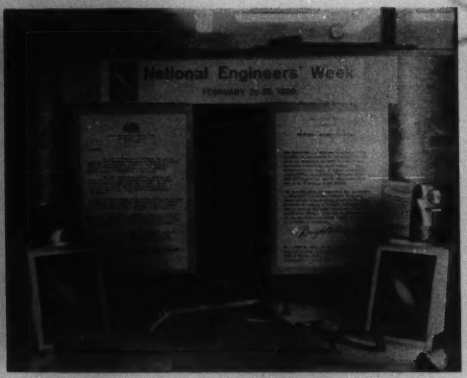
North Eastern District Meeting
Sheraton-Biltmore Hotel
Providence, R. I.
May 2-4, 1960
(Final date for †TP—Feb. 2, DPMs—Feb. 26)

*Final date for submitting papers—closed

†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

Transactions and conference papers must conform to the requirements in *Authors Guide*
For a copy, write to E. C. Day AIEE, 33 W. 39th St., New York, N. Y.

AIEE Sharon Section Activities



SHOWN AT A MEETING of the Sharon, Pa., Section (above, *left*) held March 11, 1959, in the Westinghouse Auditorium, are (*front row, left to right*): W. H. Linton, Sharon director of civil defense; V. T. Houghton, Jr., Federal-State Flood Forecasting Service; J. H. Chiles, vice-president, Westinghouse Electric Corporation; M. J. Dunn, mayor of Sharon; G. Mahaney, burgess of Sharpsville, Pa.; E. A. Winslow, chairman, Sharon Section; L. Reznor, burgess of Greenville; and (*back row, left to right*): T. R. Specht, vice-chairman, Sharon Section; A. M. Lockie, deputy director of civil defense, Sharon; R. L. Custard, secretary-treasurer, Sharon Section; C. A. Long, program committee, Sharon Section. Principal speaker at the meeting was Mr. Houghton who presented a talk on river forecasting. Above, *right*: National Engineers' Week was observed by the Sharon Section and the Mid-Western Chapter of the Pennsylvania Society of Professional Engineers with a series of informative window displays placed in local business establishments.

(Continued from p. 684)

Zebra, a Simple Binary Computer. *W. L. van del Poel* (Netherlands)
The Specification Development of a Cost-Limited Digital Computer. *M. Lehman* (Israel)
Processing Data in Bits and Pieces. *F. B. Brooks, G. A. Blaauw, W. Bucholz* (U.S.)
A New Computing Machine. *S. A. Lebedev, K. Sulim* (USSR)
Methods of Speeding Up the Operation of Digital Computers. *G. D. Monachov, I. Ia. Akushsky, L. B. Emerjanov-Iaroslavsky, E. I. Kijamko, V. S. Linsky* (USSR)
Elimination of Carry Propagation in Digital Computers. *G. Metze, J. E. Robertson* (U.S.)

Time Sharing

President: Booth (UK)
Vice-President: A. Svoboda (Czechoslovakia)
Time Sharing in Large Fast Computers. *C. Strachey* (UK)
Input and Output in the *X-1* Computers. *B. J. Loopstra* (Netherlands)
Sympathetically Programmed Computers. *W. F. Schmitt, A. B. Tonik* (U.S.)
Sur Certains Aspects de la Conception Logique du Gamma-60. *J. Bosset* (France)
Design of Concurrently Operating Computer Systems. *A. L. Leiner, W. A. Notz, J. L. Smith, R. B. Marimont* (U.S.)

High-Speed Computation and Other Subjects

President: A. S. Householder (U.S.)
Vice-President: P. Dreyfus (France)
Application of Error Correction Codes to Multiway Switching. *H. Takahasi, E. Goto* (Japan)
Logical Elements on a Majority Decision Principle and the Complexity of Their Circuit. *S. Muroga* (Japan)
A Three Valued System of Logic and Its Application to Base Three Digital Circuits. *R. Vacca* (Italy)
The Use of Cyclic Permuted Chain Codes for Digitizers. *G. C. Tootill* (UK)
The Application of the Numerical System of Residual Classes in Mathematical Machines. *A. Svoboda* (Czechoslovakia)

3. Common Symbolic Language for Digital Computers

Rapporteur: S. Gorn (U.S.)
President: A. Walther (Germany)
Vice-President: G. Hopper (U.S.)
A Propos d'un Langage Universal. *J. M. Poyen, B. Vauquois* (France)
Methods of Logical Recursive and Operator Analysis and Synthesis of Automata. *I. I. Basilevsky, Iu. A. Shreider, I. Ia. Akushsky* (USSR)
Pseudo-Code Translation on Multilevel Storage Machines. *F. G. Duncan, E. N. Hawkins* (UK)
The Problem of a Common Language, Especially for Scientific Numerical Work (Motives, Restrictions, Aims, and Results of the Zurich Conference on Algol.) *F. L. Bauer* (Germany)
Survey on the Syntactical Construction of the Zurich Recommendation of the ACM and GAMM. *J. Backus* (U.S.)

4. Automatic Translation of Languages

Rapporteur: D. Panov (USSR)
President: S. Comet (Sweden)
Vice-President: M. Mastermann (UK)
Research in Automatic Translation at the Harvard Computation Laboratory. *V. E. Giuliano, A. G. Oettinger* (U.S.)
The COMIT System for Mechanical Translation. *V. H. Yngve* (U.S.)
The Use of Machines in the Construction of a Grammar and Computer Program for Structural Analysis. *K. E. Harper, D. G. Hays* (U.S.)
Machine Translation from English to Japanese. *S. Takahashi, R. Tadenuma, S. Watanabe, H. Wada* (Japan)
Machine Translation Methods and their Application to Anglo-Russian Scheme. *I. K. Belskaia* (USSR)

5. Pattern Recognition and Machine Learning

Rapporteur: K. Steinbuch (Germany)

Pattern Recognition

President: W. L. van del Poel (Netherlands)
Vice-President: Inzinger (Austria)
Electronic Reading Machine. *H. Wada, S. Takahashi, T. Iijima, Y. Okumura, K. Imoto* (Japan)
A Quasi-Topological Method for Recognition of Line Patterns. *H. Sherman* (U.S.)
Procede Analogique de Reconnaissance des Signes par Tracage des Contours. *W. Sprick* (Germany)
Quantitative Research on Potential Methods. *Kazmierczeck* (Germany)
Information–Theoretic Aspects of Character Reading. *S. Frankel* (U.S.)

Proving Theorems

President: Bassilevsky (USSR)
Vice-President: S. N. Alexander (U.S.)
On the Recognition of Speech by Machine. *G. W. Hughes, M. Halle* (U.S.)
Report on a General Problem-Solving Program. *A. Newell, J. C. Shaw, H. A. Simon* (U.S.)
A Program for the Production of Proofs for Theorems Derivable within the First Order Predicate Calculus from Axioms. *P. C. Gilmore* (U.S.)
Realization of a Geometry Theorem Proving Machine. *H. Gelernter* (U.S.)
A Non-Heuristic Program for Proving Elementary Logical Theorems. *B. Dunham, R. Fridshal, G. L. Sward* (U.S.)
A New Method for Discovering the Grammars of Phrase Structure Languages. *R. J. Solomonoff* (U.S.)

Machine Learning

President: G. Manneback (Belgium)
Vice-President: Biermann (Germany)
Plastic Neurons as Memory Elements. *D. G. Willis* (U.S.)
Analysis of the Working Principles of Some Self-Adjusting Systems in Engineering and Biology. *S. N. Braines. A. V. Napalkov, Iu. A. Shreider* (USSR)
Experiments in Machine Learning and Thinking. *T. Kilburn, R. L. Grimsdale, F. H. Sumner* (UK)
A Machine Model of Recall. *M. E. Stevens* (U.S.)
Some Mathematical Fundamentals of the Use

or Symbols in Information Retrieval, *C. N. Mooers* (U.S.)

A Reduction Method for Nonarithmetic Data and Its Application to Thesauric Translation. *A. F. Parker-Rhodes, R. M. Needham* (UK)

Special Session on Computer Techniques of the Future

President: I. L. Auerbach (U.S.)
Vice-President: A. Speiser (Switzerland)
Program to be Announced.

Symposia

13 symposia have been set for the advance schedule. Registrants have been asked to indicate their preferences on the official UNESCO application form. Additional symposia may be organized on request to officials at the Conference. These requests will be handled within the limits of available facilities. Scheduled symposia to date include:

1. Relationship between digital and analog computing.
2. Collection, storage, and retrieval of information.
3. Automatic programming.
4. Numerical analysis on computers.
5. Influence of very-large memory designs and capabilities on information retrieval.
6. Logical organization for very-high-speed computers.
7. Methods for solving linear systems.
8. Linear programming.
9. Logical organization of very small computers.
10. Programming procedures.
11. Switching algebra.
12. Error detection and correction.
13. Machine translation.

Cincinnati First in Nation To Top Engineering Center Goals

CINCINNATI has been declared the first community in the Nation in which all Founder Society Sections, through concerted action, have surpassed their quotas in full support of the United Engineering Center fund campaign. The total pledged by Cincinnatians now stands at $45,120.

The four Cincinnati Sections of the Founder Societies which have achieved this outstanding success are: AIEE, American Society of Civil Engineers (ASCE), American Society of Mechanical Engineers (ASME), and American Institute of Chemical Engineers (AIChE). The new national engineering headquarters will be located on the attractive United Nations Plaza in New York City.

R. E. Dougherty, chairman of the National Member Gifts Campaign for the United Engineering Center, in extending his congratulations on this accomplishment said: "Cincinnati, with a long history of excellent engineering society organizations, has made a fine demonstration of how well-unified efforts can achieve important goals for the engineering profession at large."

E. S. Fields, AIEE, president of the Cincinnati Gas & Electric Co., was chairman of the Sponsoring Committee of the local campaign. L. L. Bosch, ASME, partner of Bosch & LaTour, was general chairman. Representing their respective societies on the Cincinnati Committee were: Willard Farris, AIEE, Corps of Engineers; Kenneth Pettengill, AIChE, Arnold Hoffman & Co.; and Cornelius Wandmacher, ASCE, University of Cincinnati.

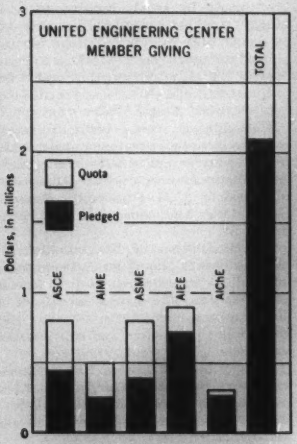
Although minimum quotas have been reached, the campaign to reach all members of the Founder Societies who have not yet pledged, including new arrivals in Cincinnati, will continue.

The statistics by societies for the four Cincinnati Sections as of April 9 were reported as shown in the table below.

In addition, word has been received that the Ohio Valley Section of the American Institute of Mining, Metallurgical and Petroleum Engineers (AIME) has pledged $6,491 or 135% of its quota. This Section of AIME, the other Founder Society, includes approximately 49 members who are Cincinnati residents.

Actual construction of the United Engineering Center building moved a step nearer this month with the selection of the Turner Construction Co. as general contractors.

Society	Number of Contribution	Per Cent of Contribution	Amount of Contribution	Per Cent of Quota
ASCE	129	60%	$ 6,522	138%
ASME	386	53%	24,500	163%
AIEE	252	59%	9,773	101%
AIChE	116	85%	4,325	135%
TOTAL	883		$45,120	



THE BAR GRAPH shows the status of member giving as of April 10, 1959. All contributions to the United Engineering Center Building Fund are tax deductible.

CINCINNATIANS mark their achievement as the first community in the Nation "over-the-top" in all Founder Society sections in the United Engineering Center campaign. The amount of $45,120 already has been pledged by 883 members. E. B. Fields, president, Cincinnati Gas & Electric Co., chairman of the Cincinnati Sponsor Group which led the member gifts campaign in the Queen City, receives a token of appreciation from the local section representatives: *(left to right)* Cornelius Wandmacher, University of Cincinnati, chairman for Cincinnati Section of ASCE; J. E. Tobey, Appalachian Coals, Cincinnati representative, Ohio Valley Section of AIME; E. B. Fields; L. L. Bosch, partner, Bosch & LaTour, general chairman and chairman for Cincinnati Section of ASME; K. H. Pettengill, Arnold Hoffman & Co., chairman for Ohio Valley Section of AIChE; W. A. Farris, U.S. Corps of Engineers, chairman for Cincinnati Section of AIEE.

Nuclear Congress Devoted to Peacetime Uses of the Atom

THE NATION'S most comprehensive series of meetings devoted to peacetime uses of the atom—the 1959 Nuclear Congress—was held in Cleveland, Ohio, April 5-10. More than 3,000 engineers, scientists, and industrial executives with an interest in nonmilitary applications of nuclear energy and radioactive materials were in attendance. The Congress, which included the 5th Nuclear Engineering & Science Conference, the 7th Hot Laboratories & Equipment Conference, the 7th Atomic Energy in Industry Conference, and the Atomfair, was sponsored by 30 engineering, scientific, and industrial organizations, and was co-ordinated by the Engineers Joint Council.

A special program was held prior to the opening of the Congress for 3,200 high school students in the Cleveland area. Following the presentation of several brief speeches, the students were admitted to the lower exhibition floors for a preview of the Atomfair.

An important feature of the Nuclear Congress was the banquet held April 8 at the Sheraton-Cleveland Hotel. The speaker was Dr. H. F. York, director, research and engineering, U. S. Department of Defense, whose subject was "Nuclear Energy and Space." Dr. York, a leader of Project Argus, stated that the recently disclosed nuclear explosions high above the earth did not create any radiation fallout hazard. He said that the blasts were widely diffused outside the earth's atmosphere.

He went on to say that the artificial band of radiation created by the blasts fell between two natural belts of radiation that girdle the earth and which were discovered only within the last year. Because of its location, the man-made aurora could easily be detected when Explorer IV passed through the belt, roughly 250 times before the telemetering devices went dead. The Argus aurora was "observable" for about 3 months after the detonations late in the summer of 1958.

Technical Sessions

Over 20 AIEE-sponsored papers were among the 100-odd technical papers presented during the Nuclear Engineering & Science Conference.

E. L. Gardner of Atomics International described instrumentation for the KEWB (Kinetic Experiments on Water Boilers) program, being conducted for the U. S. Atomic Energy Commission.

To meet the need for high-sensitivity multichannel safety systems, fully fedback operational amplifier types were developed at the Babcock & Wilcox Company laboratories at Lynchburg, Va. These systems are covered in a paper presented by R. M. Ball.

A paper by J. W. Schwartzenberg, J. M. Finan, V. S. Underkoffler, and R. N. Brey, Jr., described a simulator for the EBWR (Experimental Boiling Water Reactor). This simulator was designed to serve the threefold purpose of a mature exhibit for the 1958 Geneva Conference, an operator training device, and an experimental tool for control system studies.

Some simple approximate solutions to reactor kinetic equations for ramp inputs are outlined and explained in a paper by John MacPhee of AMF Atomics, Greenwich, Conn.

A low-cost nuclear power plant simulator for educational use was described in a paper by C. C. Scott and E. B. Dahlin, Minneapolis-Honeywell Regulator Company. The simulator is designed so that a program can be set up in a period of minutes, allowing rapid comparative studies of operating characteristics of plants operating on various programs. The equipment also lends itself readily to studies such as automatic start-up of reactors.

A high-temperature pulse preamplifier which can amplify low-level fission chamber pulses near the source has been developed at the Missile and Space Vehicle Department, General Electric Company, as reported by W. L. Frisby and E. M. Palmer. In this application, no significant size and weight penalties were caused by high temperature requirements.

A. S. Bartu of General Electric's Atomic Power Equipment Department described a dual-channel reactor protection system which utilizes commercially available components in coincidence circuits to achieve the system reliability that is required for power-plant service.

In "Transfer-Function Response of a High-Impedance Nuclear Power Channel," R. J. Allen of Atomics International presented techniques for determining the phase error introduced by instrumentation used in conjunction with pile oscillator experiments.

Circuits developed for use in MTR (Materials Testing Reactor) pulse analyzers are covered in a paper given by F. L. Petree of the Phillips Petroleum Company Atomic Energy Division. These circuits include a randomly pulsed crystal-controlled time-base generator, plug-in printed-circuit transistor modules, a magnetic-core temporary storage circuit, and a magnetic memory core drive circuit.

A paper by H. A. Brown and J. V. Rogers, both of Tracerlab, Inc., describes a remote area monitoring system offering the advantages of no zero drift, a 5-decade range, and only two monthly calibration adjustments. The detector is a small halogen-quenched Geiger-Muller tube.

The growing uses of pressure equipment require increased attention to safeguards. Some of the aspects of safeguarding high-pressure systems in nuclear plants were discussed by R. H. Scott of the Hanford Laboratories Operation, General Electric Company.

H. H. Hendon of General Electric's Atomic Power Equipment Department covered a transistorized power reactor safety system. The system consists of a flux amplifier, logic elements for flux and other input parameters, and trip actuator amplifiers.

A paper by S. N. Lehr and V. P. Mathis of the General Electric Company describes a digital start-up control for mobile nuclear reactors, including the count-rate and period circuitry.

Control system philosophy for an aircraft nuclear power plant is discussed in a paper by J. A. Russell, S. F. Hemmenway, J. L. Scharf, and P. C. Sharr, all of the Aircraft Nuclear Propulsion Department, General Electric Company. In addi-

SERPENTINE, involute, and trombone-nested tubes form heart of atomic steam generator, model of which was exhibited at Atomfair. The steam generators are being built for the 100,000-kw Enrico Fermi Atomic Power Plant by The Griscom-Russell Company, a subsidiary of General Precision Equipment Corp. P. S. Otten and J. Lode, responsible for the design, examine model showing ingenious maze of special tubes developed to produce high-temperature, high-pressure steam by transfer of heat from sodium metal made molten by a fast-breeder nuclear reactor.

tion, advantages of a power-range magnetic control system with a minimum number of moving parts are outlined.

In another paper on aircraft propulsion reactors, by P. K. Hiser, M. E. Ward, A. D. Wilcox, and R. H. Willsey, also of General Electric's Aircraft Nuclear Propulsion Department, components for a start-up control system are described. The system includes both vacuum-tube and magnetic-amplifier circuits.

An instrument for measuring flow and liquid level of process fluids at temperatures to 1,500 F and pressures to 500 psig (both conditions not imposed simultaneously) has been developed by Taylor Instrument Companies, as reported by S. A. Hluchan. It consists of a differential pressure transmitter connected by capillary lines to high- and low-pressure diaphragm seal units contacting the process fluid, a sodium–potassium alloy.

A paper by W. H. Hamilton and G. H. Conley, Westinghouse Electric Corporation, Bettis Atomic Power Division, discusses acceptance testing of pressurized water reactor power plants, with emphasis on problems which are departures from those encountered in conventional plants. Problems in planning, executing, and evaluating the test program are reviewed.

R. L. Gamblin, Princeton University, described the design and operation of a shunt-regulated 25,000-joule inductive energy storage system. Also considered in this paper are the problems of economics and coil loss resulting from the use of high-frequency components.

An instrument developed for measuring power distributions in heterogeneous reactor cores by the Atomic Energy Division, Babcock & Wilcox Company, was described in a paper by J. H. Mortensen and R. M. Ball. Measurement is accomplished by feeding irradiated fuel pins into an automatic scanning device which measures the gamma activity of the fission products along the length of the pins. The net activity of each increment of the fuel pins is automatically recorded by a digital printer.

"Transients in Logarithmic Count-Rate and Period Meters," by B. B. Barrow, SHAPE Air Defense Technical Center, and Robert Maitland, General Electric Company, is chiefly concerned with random fluctuation of the meter output, or noise. Design of differentiating networks and experimental measurements of transient response are outlined.

A paper by J. A. Dever and Louis Sickles, Minneapolis-Honeywell Regulator Company, describes a high-speed microcurrent amplifier. By use of feedback amplifier techniques, considerable improvement has been made in the stability of the familiar electrometer tube micro-microammeter.

An instrument for giving a continuous direct indication of hydrogen concentration in the primary loop of pressurized water reactors is covered in a paper by E. R. Hill and D. C. Griffith of the Swartwout Company, Cleveland, Ohio. The device, consisting of a detector installed in the process piping and a remote mounted receiver, is powered from a normal 60-cycle power line and operates, without correction, over the pressure and temperature range of the primary loop.

MODEL of boiling water reactor (BWR) propulsion system for merchant ships was on display at the Atomfair. The General Electric (GE) Atomic Power Equipment Department at San Jose, Calif., recently announced that this type system has important operating advantages over other reactor types for marine propulsion. It also has distinct advantages over conventional propulsion systems. The BWR system considered for ship propulsion is basically the same as reactor designs developed by GE for small electric power generating stations. It incorporates mechanical design features necessitated by marine service requirements. The BWR is in cutaway sphere at right with remainder of propulsion equipment to the left of the reactor.

Atomfair

The Atomfair, the nuclear industry's only major show during 1959, was sponsored by the Atomic Industrial Forum, Inc., and featured displays from more than 125 exhibitors.

The General Electric Company displayed six models including one of a boiling water nuclear plant for the propulsion of surface ships and one representing a typical plant in the "target" phase of the company's acceleration plan for boiling water reactors. The latter type plant is scheduled to produce economically competitive electric power by 1970.

Another outstanding attraction at the Atomfair was a demonstration of SNAP-III, a nuclear heat conversion generator developed by The Martin Company. The radio-isotope-fueled thermoelectric generator is one pound lighter than the model shown by President Eisenhower in January. It is 4.75 inches in diameter and 5.5 inches high and can deliver 10 kwhr over 280 days.

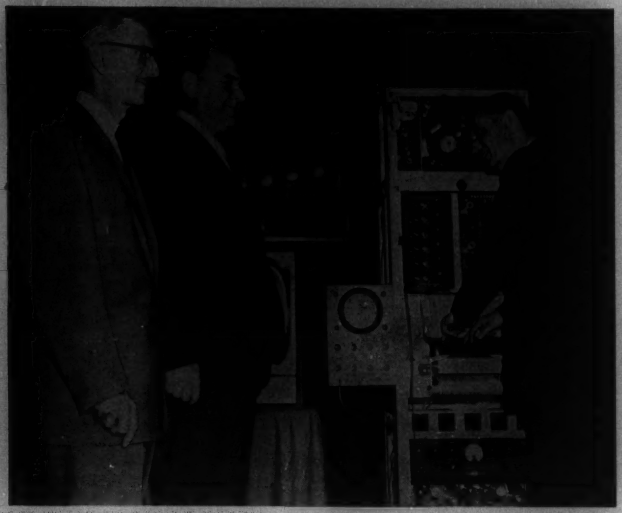
AMF Atomics Division of American Machine & Foundry Company featured a versatile high-pressure control-rod actuator. Designed for scramming the control rod by releasing a magnetically actuated latch, the actuator can provide a wide range of rod speeds and can be used at pressures up to 2,500 psi.

A radiation shielding window 8½ feet in depth, the thickest ever built, was exhibited by Corning Glass Works. It was assembled for the Atomic Energy Commission. The 9-ton window contains seven glass panes, each 9 inches thick, and 12 clear plastic sheets. It will be installed in a new flight engine test facility at the National Reactor Testing Station near Idaho Falls, Idaho.

Technical Periodicals

The technical periodicals, *Communication and Electronics, Applications and Industry,* and *Power Apparatus and Systems* contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis issued six times a year. Members may receive one subscription to any *one* of the technical periodicals for $2.50. The balance of the annual $5.00 subscription price will be paid by application of his annual dues for the year of the subscription. (Members may not reduce the amount of their dues payment by reason of nonsubscription.) Additional member subscriptions will be at the rate of $5.00. Nonmembers may subscribe on an advance annual subscription basis of $8.00 each (plus 50¢ extra for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.50 each. Discounts are allowed to libraries, publishers, and subscription agencies.

AIEE South Texas Section



Courtesy Wally's Photos

AT THE MARCH MEETING of the South Texas Section of the Institute are shown (*left to right*) F. O. December, chairman; H. E. Woelke, vice-president, Perry Shankle Co.; and the speaker, Dr. H. L. Donley of Radio Corporation of America (RCA) Laboratories, who demonstrates the RCA Electronic Music Synthesizer. Approximately 285 people attended the demonstration lecture.

Cleveland Section Prize Paper Contest

H. C. MARTIN, JR. (*right*), chairman, AIEE Cleveland Section, and J. T. Tomin (*left*), chairman, Prize Paper Committee, congratulate H. E. Jordan (*center*), Reliance Electric and Engineering Company. Mr. Jordan's paper "Synthesis of Double-Cage Induction Motor Design" won the vote of the judges and audience at the Section meeting and contest on February 19, 1959. All of the seven contestants presented papers with good technical content. Each winner received a certificate and cash award recognizing his efforts. K. W. Klein, Cleveland Electric Illuminating Company, and J. O. Gustafson, Bailey Meter Company, placed second and third, respectively.

Chicago Section Inspection Trip

The Power Group Committee of the AIEE Chicago Section Opened the 1958-59 year of Section activities with an inspection trip to Hubbard & Company's new research laboratory located just southwest of Chicago, Ill. The trip was limited to 100 people but shortly after it was announced it became apparent that many more desired to attend. Therefore, the trip was extended to a second night to accommodate a total of almost 200 for both nights.

The laboratory inspection trips were preceded by dinner and a "get-together" at a famous restaurant near the laboratory.

EJC Issues 1958 Annual Report

E. R. Needles, 1958 president of Engineers Joint Council (EJC), opens the 1958 Annual Report with a survey of the past year's achievements. Important among these were: the completion of the incorporation of EJC in New York State as a nonprofit organization; and the establishment of a Joint Committee from EJC and Engineers' Council for Professional Development to study the means of closer co-operation between these two Councils in both administration and performance, and the possible amalgamation of the two.

Following the President's Report are individual Committee Reports on Air Pollution, Atomic Energy Panel, Automation, Constitution and Bylaws, Consulting Practice, Employment Conditions, Engineering Manpower Commission, Engineering Sciences, Honors, EJC Insignia, International Relations, Labor Legislation Panel, Membership, National Water Policy Panel, Planning, Practice of Engineering, Public Relations, Recognition of Specialties in Engineering, and Transportation.

Part Two of the Annual Report includes the Constitution and Bylaws; Part Three lists the 1959 Committees; and Part Four contains the Directory and the Board of Directors, 1959.

L. J. Linde Addresses AIEE Cleveland Section

L. J. Linde, director of electrical engineering for Allis-Chalmers and manager of C Stellarator Associates of Princeton, N. J., spoke February 19, 1959, to the Cleveland Section of the AIEE on "Research in Thermonuclear Fusion for Power."

Mr. Linde, formerly with the General Electric Company (GE) in Philadelphia, Pa., was responsible for several major inventions and developments for GE, including the magne blast circuit breaker. He is the recipient of two Charles A. Coffin awards for his achievements. Author of several papers, Mr. Linde has about 35 patents.

Mr. Linde explained that the atomic

reactor operating today for power utilizes a fission reaction. He further explained that the reason for investigating the fusion reaction such as found in the hydrogen bomb was that fissionable material, like uranium, is limited in supply just as are coal and oil, while fuel for a fusion reaction, heavy hydrogen, can easily be obtained from water. Other advantages are the absence of radiation problems and radioactive waste inasmuch as the ash resulting from nuclear fusion is helium, a useful element.

The C Stellarator now being constructed at Princeton by Allis-Chalmers and Radio Corporation of America (RCA) for research is so named because it is the third model developed. "Stellarator" can be translated to mean "Star Generator." The energy is released through a process similar to that occurring naturally in stars like our own sun.

Project Sherwood is the first in which the Atomic Energy Commission has worked directly with industrial firms. C Stellarator Associates is a Management Engineering Organization set up by Allis-Chalmers and RCA to supervise the building of the C Stellarator, and is a part of Project Sherwood.

L. J. LINDE (*center*), manager of C Stellarator Associates, was the speaker at the February 19 meeting of the AIEE Cleveland Section. Shown with Mr. Linde are Section Chairman H. C. Martin (*right*) and Section Vice-Chairman E. C. Barnes (*left*).

Two Engineers To Receive Lamme Medal

For the first time since it was established in 1928, the AIEE Lamme Medal has been awarded jointly to two engineers, P. L. Alger (F '30) and Sterling Beckwith (F '49). The medal will be presented during the Institute's Summer and Pacific General Meeting, with the citation, "In recognition of their contribution to the art and science of design and application of rotating electric machines."

Mr. Alger, who is an adjunct professor of electrical engineering at Rensselaer Polytechnic Institute, was born in Washington, D.C., on January 27, 1894. He was graduated from St. John's College, Md., in 1912, and from Massachusetts Institute of Technology (MIT) in 1915. After 2 years as instructor and research assistant at MIT, and a summer on the General Electric Test Program, he served as Lieutenant in the Ordnance Department, U.S.A., at Sandy Hook and Aberdeen Proving Ground. In April 1919, he joined General Electric as an engineer in the induction motor department at Schenectady, N.Y., where he studied under Dr. E. J. Berg at Union College, receiving his M.S. degree in 1920. In 1927, he was appointed assistant engineer in the a-c engineering department, where he was concerned with the design of the Conowingo generators and other large machines. In 1930, he became staff assistant to the vice-president of engineering, where he was engaged for 20 years in the promotion and co-ordination of engineering work throughout the company. In 1950, he was appointed a consulting engineer in the motor department, where he remained until his retirement from General Electric on February 1, 1959. He is the author of some 40 papers in the AIEE *Transactions*, and has written two books: "The Nature of Polyphase Induction Machines," John Wiley & Sons, Inc., 1951; and "Mathematics for Science and Engineering," McGraw-Hill, 1957. He has contributed also to the *General Electric Review*, the Standard Handbook for Electrical Engineers, and other publications. He is a past chairman of the AIEE Committees on Rotating Machinery, Technical Program, and Professional Conduct, and of several of the Standards Co-ordinating Committees and working groups. He served as a director of the Institute from 1944 to 1948. Currently, he is chairman of the Ethics Committee of the Engineers' Council for Professional Development, a director of the New York State Citizens' Council and of the Schenectady Bureau of Municipal Research. He is a fellow of the American Society of Mechanical Engineers, American Society for Quality Control, and American Association for the Advancement of Science, and a member of The Institution of Electrical Engineers, the Societie des Électriciens Francaise, American Society for Engineering Education, American Mathematical Society, National Society of Professional Engineers, National Municipal League, and American Legion.

Sterling Beckwith was born in Carthage, Mo., on October 29, 1905. After graduation from Stanford University in March 1927 with a degree of B.S. in engineering, he entered the Westinghouse Graduate Training Course and Design School and was design engineer on large generators. During this time, he obtained the M.S. degree in electrical engineering from the University of Pittsburgh and did additional work towards a doctor's degree in physics. From 1931 to 1933, he was part-time teaching assistant at California Institute of Technology and at the same time completed work for his Ph.D. in engineering which he received *cum laude*. From 1933 to 1935, he was assistant engineer with the Metropolitan Water District of Southern California evaluating stability of their large pumping system. From 1935 to 1952, he was with Allis-Chalmers in Milwaukee, Wis., where he was design engineer and later engineer-in-charge of alternating current generators. During this period, he worked on many new developments, including the thrust type hydrogen shaft seal, synchronous condensers for arc furnace loads, the largest two-pole short-circuit test generator, a static excitation system using magnetic amplifiers, the "tube type" cooling for large motors, the largest explosionproof motor, the Manhattan Project, a special analog computer for magnetic circuits, and the first supercharged (direct cooled) generators. Since 1952, he has been working in Lake Forest, Ill., as a consulting engineer on such vari-

P. L. Alger

Sterling Beckwith

ous projects as generator cooling, transportation of liquefied natural gas at minus 258 F, fixation of nitrogen in an internal combustion engine, and improved refrigeration of fresh foods at 110% relative humidity. Mr. Beckwith is holder of over 40 patents in the aforementioned fields and has been the author of 12 technical articles. He is co-author of the Synchronous Machine Section of the Standard Handbook for Electrical Engineers. Since 1942, he has participated on nine AIEE Committees and five American Standards Association Committees. Mr. Beckwith is a member of CIGRE (Conference Internationale des Grands Reseaux Electriques), Sigma Xi, Tau Beta Pi, Eta Kappa Nu, and the Milwaukee Engineers' Society. He is a registered professional engineer in Wisconsin and Illinois.

Fortescue Fellowship Award Is Announced for 1959-60

The Charles LeGeyt Fortescue Fellowship Committee of the Institute has awarded a Fellowship for graduate study in electrical engineering during the academic year 1959-60 to Ira Richer.

G. D. Lobingier, of the Westinghouse Electric Corporation, East Pittsburgh, Pa., is chairman of the committee administering the award for the Institute.

Ira Richer

Mr. Richer was born September 25, 1938, in New York City. He entered Bronx High School of Science in 1952, graduating in 1955. He received the Mathematics Department Award in 1955; honorable mention in the Westinghouse Science Talent Search in 1955; New York State Regents Scholarship, 1955-59. Mr. Richer entered Rensselaer Polytechnic Institute in 1955, where his honors and activities included the following: McKinney prize in English, 1956; Tau Beta Pi, Eta Kappa Nu, 1958; handball team; Zeta Psi Fraternity; student member, AIEE–IRE (Institute of Radio Engineers); Mu Rho Chi (National Association of Co-operative Engineers). He graduated with the B.E.E. degree in 1959. Mr. Richer worked three assignments for the International Business Machines Corporation as a co-op student. These assignments included work in computer programming and test equipment engineering. He will be entering California Institute of Technology this year to study for an M.S. degree in electrical engineering.

The Fellowship was established in 1939 by the Westinghouse Electric and Manufacturing Company (now Westinghouse Electric Corporation) as a memorial to Charles LeGeyt Fortescue for his contributions to the electric power industry.

Dr. Fortescue, who was graduated from Queens University, Kingston, Ont., Canada, as the University's first electrical engineer in 1898, received 185 patents on electrical inventions during his 38-year career with Westinghouse.

Lamme Medal 1959 Nominations Due December 1

Special attention is directed to the fact that the names of Institute members who are considered eligible for the AIEE Lamme Medal to be awarded early in 1960, may be submitted by any member in accordance with section 1 of Article VI of the bylaws of the Lamme Medal Committee as follows:

"The committee shall cause to be published in one or more issues of *Electrical Engineering*, or of its successors, each year, preferably including the June issue, a statement regarding the Lamme Medal and an invitation for any member to present to the Secretary of the Institute by December 1, the name of a member as a nominee for the medal, accompanied by a statement of his 'meritorious achievement' and the names of at least three engineers of standing who are familiar with the achievement."

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievements of the nominee, to enable the committee to determine its significance as compared with the achievements of other nominees. If the work of the nominee has been of a somewhat general character in co-operation with others, specific information should be given regarding his individual contributions. Names of endorsers should be given as specified in the foregoing quotation.

Article V, section 2, specifies that:

"The committee in making the award shall carefully observe the limitations imposed by Mr. Lamme, that the recipient must have 'shown meritorious achievement in the development of electrical apparatus and machinery.' This shall be taken to mean that the meritorious achievement must be of such character that it has resulted or will result in the production of substantially improved electrical apparatus or machinery. Any work which meets this requirement is admissible whether it be (a) in development of the theory involved; (b) in development of the characteristics of the materials employed; (c) in development of over-all design; or (d) in development in other ways which results in substantial improvement in electrical apparatus or machinery. The words 'electrical apparatus or machinery' shall be taken to indicate discrete and self-contained devices which may or may not include mechanical moving parts without limitation as to the field of application. They shall not be taken to include transmission or distribution systems as a whole, but rather to include the apparatus and machinery that is used in making up such systems."

Results of the District Prize Papers Competition 1957-58

The winners of the AIEE District Prize Papers Competition have been announced. First prize for any *Transactions* paper prepared by a resident of the District consists of a certificate and $75; second prize consists of a certificate and $50.

District No. 1

First prize: "Water Cooling of Turbine Generator Stator Winding," G. V. Browning, C. H. Holley, J. F. Quinlan

Second Prize: "Random Paralleling of Aircraft Alternators," F. P. deMello, H. M. Rustebakke

District No. 2

First prize: "The Prestrike Theory and Other Effects in the Lightning Stroke," S. B. Griscom

Second prize: "Magnetic-Amplifier-Operated Ink Recorders," W. A. Geyger

District No. 3 No contest

District No. 4

First prize: "Characteristics of Magnetic Amplifiers Utilizing Square-Loop Core Material and Square-Wave Supply Voltage," H. H. Britten

Second prize: "On Coding for the Binary Symmetric Channel," A. B. Fontaine, W. W. Peterson

District No. 5

First prize: "Investigation of Switching Surges Caused by 345-Kv Disconnecting Switch Operation," H. L. Rorden, J. M. Dils, S. B. Griscom, J. W. Skooglund, E. Beck

Second prize: "The Development of Standards for Insulation Systems and Insulating Materials," M. L. Schmidt

District No. 6

First prize: "A Protection Plan for Distribution Feeders," J. R. Hayden, J. E. Martin, J. E. Tilson

Second prize: "Relaying Tapped Substations for Faults on High-Voltage Transmission Lines," R. W. World, C. L. Rose, J. E. Skuderna

District No. 7

First prize: "Synthesis of Control Systems Based on Approximation to a Third Order System," C. R. Hausenbauer, G. V. Lago

Second Prize: "Matrix Programming of Electronic Analog Computors." R. E. Horn, P. M. Honnell

District No. 8

First prize: "General Analysis and Stability Study of Finite Pulsed Feedback Systems," G. Farman-Farmaian

Second prize: "Certain Applications of Matrices to Circuit Theory," L. A. Pipes

District No. 9

First prize: "Transient Performance of Excitation Systems." R. L. Krahn

Second prize: "A Comprehensive Study of Magnetic Amplifier Design—Part I, A Practical Design Method," R. M. Hubbard, M. M. Bishop

District No. 10

First prize: "Three-Phase Induction Motor Control Using Static Frequency Doublers," A. Straughen, P. P. Biringer, G. R. Slemon

Second prize: "Evaluation of Single-Phase Metering Practices Based on Meter Performance and Load Characteristics," J. M. Vanderleck

Honorable Mention: "Multivariable Control System Synthesis," R. J. Kavanagh

District No. 11

First prize: "Equivalent Circuits for 3-Phase 4-Wire Induction Motors Operating on Nonsymmetrical Systems," J. T. Mitchell

Second prize: "Bay Shore Generating Station, An Analysis of Specific Electrical Features," R. May, C. M. Gardam

District No. 12

First prize: "Analog Computer Simulation of An Aircraft Parallel A-C Generating System," M. Riaz, P. E. Smith, Jr.

Second prize: "The Practice and the Economics of Applying Digital Computers to Engineering Problems," P. A. Abetti, S. B. Williams

"Unity" Step Announced by ASME

A concrete step toward "unity of the engineering profession" was disclosed recently by The American Society of Mechanical Engineers (ASME). In the future, members of 21 sister engineering societies will enjoy the privilege of attending general meetings of ASME without registration fee. At conferences sponsored by any of ASME's Professional Divisions, they will pay the same fee as that charged ASME members, usually one half the nonmember rate.

The 21 groups are those represented on Engineers Joint Council (EJC) or Engineers' Council for Professional Development (ECPD), organizations dealing with matters of profession-wide interest.

A statement by G. B. Warren, president of ASME, which accompanied the announcement said:

"We hope that, by taking this initial step, ASME is helping to demonstrate the community of interests shared by all engineers and is helping to lead the way toward greater liaison at the working level. Clearly, many of ASME's national meetings are of interest to members of our sister groups. We hope that the adjustment of registration fees will encourage them to share in the benefits of these meetings and conferences. Although this step may result in some loss of income to ASME we are confident that dollars spent in this way will pay dividends for the entire profession."

The following groups are currently represented on EJC or ECPD thereby making their individual members eligible for the privileges announced: AIEE, American Society of Civil Engineers, American Institute of Mining, Metallurgical, and Petroleum Engineers, The American Water Works Association, The American Society for Engineering Education, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., The Society of American Military Engineers, American Institute of Chemical Engineers, American Institute of Industrial Engineers, Inc., The Engineering Institute of Canada, National Council of State Boards of Engineering Examiners, American Society of

AIEE Boston Section Activities

HIGHLIGHT of a Luncheon Meeting on February 24, 1959, at Harvard University's Memorial Hall, was the presentation of the New England Award to Dr. H. E. Edgerton, professor of electrical measurements at the Massachusetts Institute of Technology (MIT) and chairman of the board of Edgerton, Germeshausen & Grier, Inc. The meeting was held during Massachusetts Engineers' Week, sponsored by the Massachusetts Society of Professional Engineers and the Engineering Societies of New England (ESNE). Shown at the presentation are: *(left to right)* Dr. C. S. Draper, director of MIT Instrumentation Laboratories, who spoke on "Engineering in the Space Age"; Dr. Edgerton; J. C. Hitt, Jackson & Moreland, Inc., chairman of the AIEE Boston Section, and past president of the ESNE, which presents the award annually to the "Outstanding Engineer in New England"; and L. J. Weed, Boston Edison Company, chairman of the Luncheon Meeting, and past chairman of the Boston Section.

Courtesy Boston Globe

CUTTING THE CAKE for the 75th Anniversary of AIEE at a Boston Section Dinner Meeting on February 10, 1959, at the Hotel Lenox, are: *(left to right)* Leon Campbell, Jr., and Section Chairman J. C. Hitt. Mr. Campbell, who has been in charge of the Moon Watch Program for the Smithsonian Astrophysical Observatory since its inception, gave an interesting report on satellite sighting by 230 moon watch teams located around the globe.

Agricultural Engineers, American Institute of Plant Engineers, American Institute of Consulting Engineers, Western Society of Engineers, Louisiana Engineering Society, Engineering Societies of New England, Inc., South Carolina Society of Engineers, Los Angeles Council of Engineering Societies, Kentucky Society of Professional Engineers, Consulting Engineers Council.

Members of the Institution of Mechanical Engineers of Great Britain, and the American Rocket Society continue to be eligible for the same privileges under previously announced reciprocal agreements between ASME and those societies. Members of Engineering Institute of Canada, represented on ECPD have also been eligible for some time.

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until June 26. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., on or before June 26.

59-150 High-Voltage Rectifier Transformer Problems. *T. L. Wilson*

59-200 A Transmission Design for Closed-Circuit Educational Television. *W. L. Wall*

59-256 Three-Phase Induction Heating Coils. *N. V. Rose*

Preprints may be purchased at 40¢ each to members, 80¢ to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th St., New York 18, N.Y.

Los Angeles Section Meeting

Stanart Photo

THE SUBJECT of "Unconventional Power Sources for Aircraft and Missiles" was discussed at the March General Meeting of the Los Angeles Section of the Institute. Leading the discussion were (*left to right*) the speakers, N. H. Nelson, and Dr. D. B. Mackay, both of North American Aviation, Inc., Missile Division; and the Section officers, Fred Foulon, vice-chairman; E. D. Barcus, chairman; and Robert Milmoe, secretary-treasurer. The speakers presented a survey of unconventional electric power sources for airborne applications and problems encountered with these devices. Mr. Nelson discussed a survey of secondary power requirements for aircraft and space vehicles of the near future, coupled with a discussion of energy sources and energy conversion techniques that show promise as unconventional power sources. Dr. Mackay talked on a solar-turbo plant design for airborne vehicles.

Employment Service Announces Officers

The Engineering Societies Personnel Service (ESPS)—San Francisco Advisory Committee named officers for its 33rd year from the most recent of a long line of representatives appointed by the local sections of Civil, Mechanical, Electrical, Mining, Marine national engineering societies, and the Engineers Club at a regular meeting attended by National President E. O. Kirkendall and National Director H. N. Appleton. Dr. Kirkendall, also executive secretary of the Mining Engineers, commented that the Committee has admirably guided the San Francisco office in providing employment assistance to engineers in the Pacific and Mountain States.

Officers elected were: Chairman Morris Weitzner, Society of Naval Architects and Marine Engineers (SNAME), Bethlehem Pacific Shipbuilding; Vice-Chairman Ben L. Raffin, American Society of Civil Engineers (ASCE), Rothschild, Raffin & Weirick; Secretary Eric Salo, American Society of Mechanical Engineers (ASME), Pacific Gas & Electric; Treasurer R. M. Stewart, American Institute of Mining, Metallurgical and Petroleum Engineers (AIME), California State Division Mines; Assistant Secretary M. W. McLaren (AIEE), Electrical Division Bechtel; Assistant Treasurer C. K. Lewis, Engineers' Club of San Francisco (ECSF), Bechtel; Recorder N. D. Cook (ESPS); J. R. Decker, Western Representative ESPS.

San Francisco Advisory Committee announces: M. W. McLaren accepted appointment of AIEE Section Chairman M. G. Lewis, relieving H. N. Skow (AIEE) of Westinghouse Electric Corporation, who served for 2 years.

R. H. Stewart accepted appointment of AIME Section Chairman Lawrence Kett, relieving L. A. Norman (AIME), of Equipment Engineers, who served for 3 years.

C. K. Lewis accepted appointment of ECSF President J. A. Campbell, relieving L. L. Wise (ECSF) of *Engineering News-Record*, who served for 8 years and completed Committee service as chairman.

AIEE Richland Section Presents Television Program

Members of the Richland Section presented a half hour "live" television program entitled "Prologue to the Future" over the Cascade Television Network from 6:30 to 7:00 p.m. on February 25, 1959. The purpose of the program was to commemorate the 75th Anniversary of the Institute. Approximately 100,000 families in eastern Washington, northeastern Oregon, and central Idaho viewed the program.

The Section's four Technical Study Groups—Transmission and Distribution, Instrumentation, Industrial Control, and Nucleonics—described their activities by using slides and working models. The Distribution Group showed slides describing the generation, transmission, and distribution of electric power. The Instrumentation Group representative showed a dis-

play of various common electric instruments and described their application in both home and industry. The industrial control commentator described an electric relay and demonstrated its application for controlling industrial processes and the automatic washing machine. The representative from the Nucleonics Group talked about the "Fail-Safe Theory" as applied to reactor controls. He showed a working model to describe its application in reactor safety controls.

The program also included a commentary on the objectives of the AIEE, how it functions, and what it does for its members. The program closed with remarks about the electrical engineer's contributions in the past and the probable developments of the future.

Other activities to commemorate the Institute's Anniversary were: displays in public places, talks to clubs and organizations, and providing speakers to schools. As a result of the television program, requests have been received from various schools to present additional talks on the working models used in the television show, to various classes. It is planned to continue these talks and demonstrations throughout the remainder of the school year.

Photography by R. A. Clemensen

RICHLAND SECTION'S television show "A Prologue to the Future," commemorating the 75th Anniversary of AIEE, was presented by: (*left to right*) L. P. Reinig; C. R. Robinson; F. J. Cunningham; J. L. Deichman; W. E. Triplett; C. M. Salina, moderator; I. M. A. Garcia, producer; and R. S. Hammond.

6th National Symposium on Reliability and Quality Control

The 6th National Symposium on Reliability and Quality Control will be held at the Hotel Statler, Washington, D.C., January 11-13, 1960. Abstracts must be submitted by June 15, 1959.

An abstract shall consist of: title of the paper—not to exceed 50 letters including spaces; author's name, position, company, or military affiliation—where paper is joint work, indicate who would present the paper. The abstract should not be greater than two pages in length, roughly 800 words or less. Each abstract must have 10 copies for review circulation use by the Committee. Since the abstract will be the prime reason for final paper selections, it should indicate the following factual data: new approach, success achieved, and confirmation of theory. Ten copies of a biographical sketch of each author or speaker must accompany each abstract.

Authors will be notified as to status of acceptance during the week of July 20, 1959. Detailed instructions will be sent to authors by September 14, 1959. Final paper must be submitted by October 15, 1959.

All abstracts to be submitted to: M. M. Tall, 50 Flamingo St., Levittown, Pa.

Los Angeles Section Hears About "Atlas in Orbit"

The "Atlas in Orbit" was the subject of Karel Jan Bossart at the February dinner meeting of the Los Angeles Section of the Institute.

Mr. Bossart is assistant to the vice-president, engineering, Convair Division of General Dynamics Corporation, with the responsibility for missiles and space exploration programs. His talk included a brief survey of the theory and history of rockets and space vehicles; a description of the building of the Atlas missile, and of the steps taken to insure its reliability; and a discussion of the work required to place the missile in orbit.

J. R. Killian Receives the 1959 Washington Award

J. R. Killian, Jr., President Eisenhower's first special assistant for science and technology research, was the principal speaker at the 1959 Washington Award Dinner held in Chicago, Ill., April 13. Dr. Killian received the 1959 Award at the Furniture Club of America, ". . . for exceptional leadership and achievement in scientific and technological education and distinguished service to his country and mankind."

Before he accepted the newly created post on the President's Cabinet, Dr. Killian was the first alumnus of the Massachusetts Institute of Technology (MIT) to serve as its president. He held that position from 1949 until he was called to Washington in 1958. Recently he was elected chairman of the MIT Corporation,

E. D. BARCUS (*right*), chairman of the Los Angeles Section of the Institute, welcomes the speaker for the February meeting, Karel Jan Bossart (*left*), assistant to the vice-president, engineering, Convair Division of General Dynamics Corporation, who discussed the Atlas missile.

Stanart Photo

a full-time post to which he will return when he completes his assignment in Washington.

The Washington Award is the highest national honor given to an engineer by his fellows. It is conferred on the recommendation of a commission representing the AIEE, American Society of Civil Engineers, American Institute of Mining, Metallurgical, and Petroleum Engineers, American Society of Mechanical Engineers, and Western Society of Engineers. The Washington Award was established and is administered by Western Society of Engineers.

Dr. Killian's address was titled "New Sights for Engineers."

5th National Symposium on Reliability and Quality Control

The success of the 5th National Symposium on Reliability and Quality Control held at the Bellevue-Stratford Hotel in Philadelphia, Pa., January 12-14, 1959, indicates the rising interest in reliability in the electronic industry. Between 1,100 and 1,200 engineers, scientists, and executives from the United States and Western Europe participated in the 3-day Symposium.

One of the highlights of the Symposium was the attendance of four delegates from the USSR. These gentlemen brought four technical papers with them. A "hurry-up" executive session on Sunday night resulted in a decision to allow the Russians to present one of the four papers on Monday evening. The paper presented indicated that the Soviets are very active in the field of reliability and are probably keeping well abreast of the state of the art. There were, however, no indications as to the practical applications or success of the reliability programs to the USSR.

An estimated 1,000 people attended the annual banquet held Tuesday night. Three awards were presented. Mrs. Mary Carhart received the American Society for Quality Control (ASQC) Electronic Division Award for Achievement in Reliability on behalf of her husband, the late Dr. Richard Carhart. The IRE–PGRQC (Institute of Radio Engineers–Professional Group on Reliability and Quality Control) Award for outstanding contribution to the field of reliability was presented to Dr. W. H. Pickering, director of Jet Propulsion Laboratories, California Institute of Technology.

The top award of the evening, the Annual Award for the Best Technical Paper at the previous Symposium, went this year to Ralph Brewer, General Electric Company, Ltd., of Wimbley, England.

Captain D. R. Hull, president of the Electronic Industry Association, gave a challenge to industry in an address titled "Is Your Customer Satisfied?" It pointed out the ever-increasing need for reliability not only in the military field, but in the field of consumer goods as well.

The management of the Symposium this year decided to try a tutorial session for the benefit of those engineers new to the reliability field, to which the response was overwhelming.

Another unique feature of this year's Symposium is the fact that every technical paper was received in time to be printed in the Transactions. This is a unique, if not singular, accomplishment on the part of the Symposium Program Committee.

The Management Committee for the 1960 Symposium have been selected and will be under the able chairmanship of Clifford Ryerson of the Radio Corporation of America. The 6th National Symposium will be held at the Statler Hotel, Washington, D.C., the second week in January 1960.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

Charlotte Subsection Organizes Technical Groups

The Charlotte Subsection of the Institute reports two technical groups organized in November 1958: the Substation, Transmission, and Distribution Group with 26 enrolled members; and the Industrial Power and Control Group with 24 enrolled members.

Each group has met monthly since November to discuss technical subjects. Some of the topics discussed at these meetings are as follows: all-aluminum substations, stability of transmission systems, series capacitor applications, single-phase vs 3-phase transformers, system and equipment grounding, magnetic amplifiers and regulators, cable applications and construction economics, switchgear applications, short-circuit currents. It has been the practice for discussion subjects to be chosen by vote in advance of each meeting with a member assigned to plan and lead the discussion.

PRESENT AT A RECENT MEETING of the Charlotte Subsection Industrial Power and Control Technical Group (*above, left*) were (*left to right*) M. M. Smith, Duke Power Co.; Jack White, B. O. Vannort Engineers, Inc.; H. C. Byrd, Jr., Duke Power Co.; Brice Tarlton, B. O. Vannort Engineers, Inc.; H. K. Burriss, Duke Power Co.; M. H. Poole, Duke Power Co.; C. C. Earnhardt, Duke Power Co.; R. H. Walton, Duke Power Co.; D. E. Johnson, General Electric Company; B. M. Rice, Duke Power Co.; Roger Brown, Duke Power Co.; Paul Raasch, Westinghouse Electric Corporation. Not shown are Chairman C. J. Wylie, and Secretary C. M. Gadsden, both of Duke Power Co. *Above, right:* At a meeting of the Charlotte Subsection Substation, Transmission, and Distribution Technical Group were: (*left to right*) D. S. Rego, Duke Power Co., secretary; M. T. Hatley, Duke Power Co.; H. M. Bankus, General Electric Company; H. C. Byrd, Duke Power Co.; C. E. Poovey, Duke Power Co.; Don Dartnall, General Electric Company; Joe Major, Duke Power Co.; B. M. Rice, Duke Power Co.; Dan McConnell, Southern Electric Equipment Co., chairman; F. G. Dellinger, Southern Bell Telephone & Telegraph Co.; J. R. Pope, Westinghouse Electric Corporation; G. S. Poole, Southern Bell Telephone & Telegraph Co. Each group has met monthly since November to discuss technical subjects.

Session on Extra-High-Voltage Systems

One of the outstanding events of the American Power Conference, March 31-April 2, 1959, in Chicago, Ill., was the Session on Extra-High-Voltage Systems. Among the speakers was B. P. Lebedev, electrical engineer, Ministry of Power Station Construction, Moscow, one of the four delegates from the USSR, who presented a paper, "The Development of Extra-High-Voltage Systems in the Soviet Union." The paper included a discussion of the engineering features of the existing 400-kv system, of transmission systems at 500-kv to be put into operation during 1959, and of new 330-kv systems for the interconnection of power centers which are comparatively near to each other.

H. W. Haberl discussed the 300-kv system of the Quebec Hydro-Electric Commission, and L. Firestone the 345-kv system now under construction in Ohio by the Ohio Edison Company. A study dealing with the important problem of underground cables for voltages up to 500-kv entitled "Extra-High-Voltage Cable Research—Challenge of the Future" was presented by C. S. Schifreen, Philadelphia Electric Company.

The Conference, now in its 21st year, and sponsored by AIEE and other national engineering societies, as well as by a number of universities, was attended by some 3,000 engineers.

SPEAKERS AND OFFICERS of the Session on Extra-High-Voltage Systems at the American Power Conference were: *(left to rgiht)* H. A. Frey, co-chairman of the session; C. S. Schifreen, Philadelphia Electric Company; B. P. Lebedev, Ministry of Power Station Construction, Moscow, USSR; E. T. B. Gross, chairman of the session and chairman of the Electric Program Committee of the American Power Conference; H. W. Haberl, Quebec Hydro-Electric Commission, Montreal,

Electrical Engineers Hear Talk on Semiconductors

Semiconductors, their theory of operation and application, was the subject of A. M. Christian of the Westinghouse Electric Corporation, Chicago, Ill., at a meeting of the AIEE Northeastern Wisconsin Section held April 2, 1959. Some 67 members heard this interesting discussion.

Mr. Christian explained the principles and uses of semiconductors. He said that the whole thing is so new that there are many misconceptions and misunderstandings. The speaker reviewed the history of early semiconductors, such as the cat whisker detector used in the early crystal radio receivers and the copper oxide rectifiers used to change alternating to direct current. Mr. Christian said that during World War II, germanium became popular and for the last 10 years we have used germanium as well as silicon. He explained further how these materials made possible the modern transistors and rectifiers used in much of the electronic equipment today.

The speaker went on to explain that we have only seen the beginning of transistors and that much of the progress in the future will be in the geometry of these devices and materials.

He said that silicon carbide transistors built by Westinghouse will be used in missiles and will have to operate under temperatures of 500 C.

The transistors that most of us are familiar with today, Mr. Christian explained, are used in hearing aids, portable radios, etc. Transistors are of great importance to us in guided missiles and satellites because of their ruggedness, compactness, light weight, small physical size, and dependability.

Mr. Christian discussed a new type of power transistor which his company developed in the last year. This unit acts as a switch and the device is called a dynastor. This device will take the place of a thyratron. Thyratrons are gas-type tubes presently used for rectifying and control applications in industry. He said that the dynastor is only being made at present in sample quantities but that they hold great promise in the control field of the future.

The speaker discussed the sensitivity of some of the new semiconductors recently developed by Westinghouse to infra-red radiation and temperatures capable of picking up energy from a satellite, making it possible, therefore, to track the satellite by the heat radiated. He also mentioned a device using this new material which actually measured the operating temperature of a bearing accurately from a distance of 15 feet.

In a discussion on thermoelectrics, he said that Westinghouse Company has been developing thermoelectric materials which they have used experimentally in building thermoelectric generators which produce a sizable amount of electric power from di-

SHOWN AT A RECENT MEETING of the Northeastern Wisconsin Section of AIEE are: *(left to right)* A. O. Fitzner, Gidding & Lewis; Art Lins, Westinghouse Electric Corporation; A. M. Christian, Westinghouse Electric Corporation; and W. L. Sykes, Miller Electric Mfg. Co., Inc.

rect heat. He added further that, although at present this type of generator is in the experimental stage, it is feasible that large amounts of power may be generated in the future by this new device since efficiencies compared with today's modern steam generating plants are anticipated.

The speaker also mentioned devices being built by his company using this new material which will revolutionize the refrigeration industry because cooling can now be achieved by passing a current through devices made of this new material which will provide cooling. This new system will be so practical and economical that the present day compressor type refrigerator will soon become obsolete. He added that Westinghouse may have such a refrigerator on the market by late 1960.

W. L. Sykes, chief electrical engineer at Miller Electric Manufacturing Company in Appleton, Wis., conducted the meeting.

1959 Edition of "Who's Who in Engineering"

The 1959 edition of "Who's Who in Engineering," a comprehensive biographical volume of the Nation's outstanding engineers, which also includes a directory of engineering and engineering-connected groups, has recently been published.

This is the 8th edition of the publication, produced under standards of qualification established by the Advisory Committee of Engineers Joint Council. Approximately 18,000 engineers are included in this volume.

In addition to alphabetical indexing, the new volume contains a convenient geographically divided index as well as the directory of engineering groups on both state and national levels.

Designed to serve a wide area, not only of the engineering profession but also of those individuals and organizations related to engineering, the 1959 edition, because of its added coverage, is in greater demand than any previously published.

"Who's Who in Engineering" is published by the Lewis Historical Publishing Company, Inc., 265 W. 14th St., New York 11, N. Y.

Search Started for Outstanding Electrical Engineer

Eta Kappa Nu, national electrical engineering honor society, has begun its 24th annual search for the nation's outstanding young electrical engineer. Eligible for the Society's award is any man who on May 1, 1959, has been graduated not more than 10 years from a course in electrical engineering at an American or Canadian college or university and who is not more than 35 years of age.

The Eta Kappa Nu recognition of the outstanding young electrical engineer is intended to emphasize among electrical engineers that their service to mankind is manifested not only by achievements in purely technical pursuits but in a variety of other ways as well. Selection is made on the basis of the candidate's record of achievement in his chosen work; in his service on behalf of his community, state, or nation; in his cultural or aesthetic development; and in the service rendered to his profession.

Eta Kappa Nu, the sponsor of the annual award, is the national electrical engineering honor society founded at the University of Illinois in 1904. The organization has more than 28,000 members, 71 college and 12 alumni chapters in the principal cities of the United States.

Selection of the 1959 Recognition Award winner as well as possible honorable mention recipients will be made in the fall by a Jury of Award consisting of several leaders in the electrical engineering profession. The award will be presented at a banquet in New York, N. Y., in February 1960.

To assist the Jury of Award in their deliberations, each year the nominations for the Outstanding Young Electrical Engineer are given a preliminary processing and evaluation by the Society's Award Organization Committee. This group arranges for collection of references and other supporting data of use to the Jury of Award in the final judging.

Every effort is made to secure nominations on a nation-wide basis. Last year the records of 76 candidates, representing all the geographical areas of major engineering activities in the country, were scrutinized by this group.

The Committee membership for 1959 under the chairmanship of J. H. Craig includes Robin Beach, L. Dwon, J. Farley, W. Groth, N. S. Hibshman, C. T. Koerner, E. S. Lee, B. F. Lewis, J. W. Montstream, J. H. Mulligan, Jr., and R. J. Wilkinson.

Nomination forms may be obtained from The Executive Secretary, Eta Kappa Nu Association, P.O. Drawer 447, Dillsburg, Pa. Nominations should be returned to Dillsburg not later than May 31, 1959; nominations received after that date will be processed, but dossiers may not be complete when the Jury of Award meets in October.

Michigan Section Sponsors IEPS Course

For the second consecutive year, the Michigan Section of the AIEE sponsored a course in Industrial Electric Power Systems (IEPS). The course consisted of a series of eight lectures beginning on October 22 and ending on December 18, 1958, and was conducted both in Jackson and Detroit, Mich.

The course was intended for plane operation managers, maintenance personnel, electrical engineers, contractors, and other individuals concerned in putting electric power to use in a plant or commercial building.

The text for the course was the AIEE Red Book publication "Electric Power Distribution for Industrial Plants." Authorities in the design, operation, and maintenance of industrial power systems gave lectures covering trends in design of industrial power system; underground circuits and wiring materials; principles of protective relay application; fundamentals of fault current and calculation; system and equipment grounding and lightning protection; circuit opening devices, transformers, and substations; nominal system voltages and the determination of voltage drops; and relative costs of industrial distribution systems.

Success of the course is indicated by the fact that approximately 200 persons attended and that it was a repeat of a similar course sponsored by the Michigan Section last year in Detroit. Credit for its success goes to the lecturers from various industries and to the members of the Educational Committee under the chairmanship of G. S. Roy of Consumers Power Co., Jackson.

J. ST. ANDRE, Kaiser Aluminum & Chemical Co. (*at podium*), discusses trends in design of industrial power systems during a session of the Industrial Electric Power Systems Course sponsored by the AIEE Michigan Section. This session was held in Detroit, Mich.

Wear Your ◆ AIEE Badge

OF INTEREST TO STUDENT MEMBERS

EJC To Sponsor U.S. IAESTE Committee

Engineers Joint Council (EJC) has now become the sponsor for the United States Committee of the International Association for the Exchange of Students for Technical Experience (IAESTE), and its secretariat is now located in EJC's headquarters at 29 W. 39th St., New York 18, N. Y. The announcement of the change was made recently by E. R. Needles, president of EJC and by U. S. Committee for IAESTE.

IAESTE is an international, non-governmental nonprofit organization founded at London University's Imperial College in 1948 for the purpose of providing on-the-job training in foreign industry for student engineers and scientists. Its initial 10 Western European member countries began the program with an exchange of 920 students. At the close of 1958, there were 39,996 students who had been in this international exchange program among its 26 member countries. Policy for IAESTE stems from its Annual Conference of representatives of member nations, with operational responsibilities resting with each country's own Committee. Josef Wischeidt, Jr., is the executive secretary of the U. S. IAESTE Committee.

The IAESTE has been sponsored by the Institute of International Education since 1955. It is felt that EJC will make an excellent sponsor for IAESTE because of its great interest and close contact with science and engineering as represented by industry. Within EJC, IAESTE will be closely allied with EJC's Committee on International Relations, according to Mr. Needles, who announced EJC's new responsibility.

"The IAESTE program is directly concerned with engineering and science students and industrial experience on an international level. Its activities are, therefore, of direct concern to the EJC Committee on International Relations and its responsibilities of furthering engineering relationships through engineering and industrial organizations."

"It is vitally important that this activity be maintained and increased," continued Mr. Needles. "This is very much in line with the recommendations of the American Society for Engineering Education and Engineers' Council for Professional Development, which foresaw the need for increasing this country's participation, on a nation-wide basis, in this exchange program. Engineers Joint Council is happy, indeed, to undertake the responsibility for administering this program, which fits so importantly into EJC's international relations activities."

In the operation of the program itself, advanced university students use the facilities of the U.S. IAESTE Committee (now at 29 W. 39th St., New York 18, N.Y.) to arrange for training in the industrial techniques of another country. At the same time, foreign students come to the United States for a training experience with American industry. The program is reciprocal, and the number of American students who can train in a foreign country depends upon the number of foreign IAESTE students who will train in the United States. Participating United States companies pay a nominal fee to cover administration costs. Each American student interested in a training experience abroad is charged a nominal registration fee. Students also pay their own travel expenses to the country of their choice. Once there, however, they earn a maintenance allowance which covers living expenses during the training period.

It is expected that the executive secretary and staff of IAESTE will also assume some of the activities of EJC's Committee on International Relations.

The United States IAESTE Committee includes: Chairman J. K. Wolfe, manager, advanced degree personnel, General Electric Company; M. M. Boring, manpower consultant; H. E. Bumgardener, assistant to the president of Detroit Edison Company; W. T. Cavanaugh, executive director, National Office Management Association; F. R. Erskine Crossley, professor of mechanical engineering, Yale University; S. B. Ingram, director of education and training, Bell Telephone Laboratories; Willard Johnson, vice-president, U.S. National Student Association; H. A. Meyerhoff, executive director, Scientific Manpower Commission; W. E. Reaser, assistant secretary, American Society of Mechanical Engineers; P. T. Sowden, consultant; Arthur Tichenor, foreign student adviser, Purdue University; Andre Varchaver, past secretary of U.S. IAESTE Committee; and Josef Wischeidt, Jr., executive secretary, U. S. IAESTE Committee.

Two-Way Electrical Classroom Communication System

A two-way electrical classroom communication system developed at the Pennsylvania State University enables an instructor to know how well he is succeeding in teaching his class.

It also enables the student to know immediately whether his answers to questions are right or wrong and this immediate knowledge of the result of his answer, it is believed, may facilitate learning.

The device, designed and built at the University with a $5,000 grant from the Westinghouse Electric Corporation, has been named "MARI." The full title is Motivation and Response Indicator.

The system originally was conceived by

AIEE Section Encourages Students

Morning Star Photo

AT A DINNER MEETING held during National Engineers' Week, the Rock River Valley Section (Rockford, Ill.) of the Institute was host to more than 40 high school students interested in engineering careers. Above, the principal speaker John Gammell *(left)* talks with student John Roseberg *(center)* and Section Chairman N. G. Alvis *(right)*. Mr. Gammell is in charge of graduate training at Allis-Chalmers Manufacturing Company in Milwaukee, Wis. The Rock River Valley Section also supplies AIEE members to the high schools for counselling work.

Cooper Union Engineering Building

COOPER UNION's new building for its free School of Engineering is shown by the architect's drawing *(left)* as it will look when erected just north of Cooper Union's century-old Foundation Building. Voorhees Walker Smith Smith & Haines are the architects.

Courtesy Voorhees Walker Smith Smith & Haines

Dr. H. S. Hoffman, assistant professor of psychology, as a result of his work in the field of learning theory.

With the support of Dr. M. A. Williamson, dean of the College of Engineering and Architecture, and Dr. O. E. Lancaster, Westinghouse professor of engineering education, a project was launched to determine the merits of such a system for college student instruction. At present, it is utilized in the teaching of engineering and psychology courses and the learning achievements of the students are noted.

The device consists of an instructor's station and small individual stations for each student. The instructor poses a question that has one of two alternative answers, then feeds the correct answer into the system.

The sudent presses one of two buttons and learns immediately whether he was right or wrong. The instructor too can tell immediately which students answered the question correctly and the percentage of students answering correctly.

The device was built by a team of students, working under G. L. Crossley, assistant professor of electrical engineering. The students were J. W. Finkbeiner, Tatamy; S. A. Diehl, Richlandtown; and R. L. Sheetz, and L. E. Kane, both of Bellefonte.

AT THE 5TH ANNIVERSARY MEETING of the Vermont Subsection of the AIEE, first chairman H. M. Smith is preparing to cut a birthday cake, surrounded by student participants at the meeting, which was devoted to student papers. Shown are: *(left to right)* Brigitta Brand, secretary, University of Vermont Student Branch; W. J. Rizzi, chairman, Norwich Student Branch; H. A. VanDine, vice-chairman, Vermont Subsection; W. H. McAnney, chairman, University of Vermont Branch; H. M. Smith, first chairman, Vermont Subsection; Charles Petronis, treasurer, Norwich Branch; and Frederick Tellion, chairman of publicity committee, Norwich Branch.

Awards and Medals from Colleges and Universities

Columbia University, New York, N. Y. R. A. W. Carleton, president and founder of the Carleton Company, Inc., construction engineering firm, has been named the 1959 recipient of the Egleston Medal, Columbia University's highest award for "distinguished engineering achievement," sponsored by the Columbia Engineering School Alumni Association.

Dr. J. R. Dunning, dean of the Columbia University School of Engineering, who has played a key role in the development of the United States atomic energy program, has been awarded the Michael I. Pupin Anniversary Medal for "distinguished service to the nation."

Washington University, St. Louis, Mo. G. V. Williamson, vice-president, production and distribution, Union Electric Company, St. Louis, Mo., received one of the first Engineers' Day Honor Awards presented by the Washington University School of Engineering.

University of Missouri, Columbia, Mo. The College of Engineering and the Engineering Foundation of the University of Missouri has presented the Missouri Honor Award for Distinguished Service in Engineering to four prominent engineers, all alumni of the University: E. L. Anderson, chief engineer (retired) for the St. Louis-San Francisco Railway; H. M. Bosch, professor of public health engineering at the University of Minnesota; Dr. J. F. Calvert, professor of electrical engineering and head of the department at the University of Pittsburgh; and Mason Vaugh, retired professor and head of agricultural engineering at Allahabad Agricultural Institute, Allahabad, India.

Student Engineers Present Technical Papers

Five student electrical engineers from Norwich University and the University of Vermont delivered technical papers at a March meeting of the Vermont Subsection of the AIEE held at Norwich.

The meeting, held in Partridge Hall on the Norwich campus, was presided over by H. A. VanDine, Jr., vice-chairman of the Vermont Subsection, who is with the General Electric Co. in Burlington. The meeting was preceded by a dinner marking the 5th Anniversary of the Subsection's organization, with Prof. Howard Smith of the University of Vermont, who was the organization's first chairman, present to help cut the birthday cake.

The post-dinner session was given over to the students. Participants, all seniors, and the titles of their papers, follow: W. J. Rizzi, Norwich, from Barre, Vt., "Solid-State Developments"; Lester Leland, Norwich, from Woburn, Mass., "A Sweep Generator for the Medium-Frequency Range"; Miss Brigitta Brand, University of Vermont, New Rochell, N. Y., "Switching Algebra"; R. A. DeForest, University of Vermont, Troy, N. Y., "A Constant Horsepower Machine"; and W. H. McAnney, University of Vermont, Brattleboro, Vt., "Paradox Lost."

AIEE Students Tour Communications Facilities

On January 26, 1959, 50 student AIEE members from the University of Illinois, Navy Pier Branch at Chicago, toured the communications facilities of the Illinois Bell Telephone Company. AIEE members from the Illinois Bell engineering department served as guides for this tour. W. T. Larner, treasurer of the Chicago AIEE Section and general appraisal engineer of Illinois Bell Telephone Company, represented AIEE at a noon luncheon for the students. J. H. Enenbach, Illinois Bell's training engineer, spoke to the students on "The Electrical Engineer in the Bell System."

The tour highlighted the electrical engineering problems in the Bell System telephone communications work. The students witnessed the switching of the New York television network shows as they were switched in Chicago to other Western cities. Explanations and demonstrations of microwave techniques, radio relay, and L Carrier systems were also included in the day-long tour. This inspection trip was the second one presented by Chicago AIEE Section to familiarize student members with the actual work of electrical engineers in industry.

"The Electrical Engineer in Industry" tour shows AIEE students from the University of Illinois undergraduate school at Chicago examining Direct Distance Dialing (DDD) card translators at Illinois Bell Telephone Company's communication facilities.

Illinois Bell Telephone Co. Photo

Alabama Section Is Host to AIEE Student Branches

On Monday, February 9, 1959, the Alabama Section of AIEE, through its Student Branch Co-operation Committee, was host to the Student Branches of AIEE at the University of Alabama and Auburn (Alabama Polytechnic Institute). An inspection trip was planned for both schools and the students were invited to attend the regular monthly Section meeting held at the Redmont Hotel.

The University of Alabama students (approximately 60) met in the Alabama Power Company Auditorium about 2:00 p.m. After a talk by W. R. Brownlee, power pool manager, outlining progress made and problems yet unsolved in the economic dispatch of power, the students visited the Southern Services power pool office, located in the general office building of the Alabama Power Company, to see the "Early Bird" in operation. This device, which was the world's first cost-of-power-delivered computer, continuously provides the economic dispatch of power for the entire Southern Company system in four states. It is known as the "Early Bird" after its inventor, E. D. Early, vice-president of Southern Services, Inc.

The students also visited the Sixth Avenue telephone building. Divided into four groups by R. J. Barefield, North Alabama division engineer of Southern Bell Telephone Company, the students saw the long distance dialing equipment, local dial exchange, television monitor for the network program, toll switchboard, and various other electronic equipment and machinery which provide telephone service to the Birmingham area.

The Auburn students (approximately 35) met at the Tennessee Coal & Iron Division (TCI), U. S. Steel Corp., office building about 11:00 a.m. They were introduced to Jack England, general procedure supervisor for TCI, who explained the various types of problems that are solved by the IBM *705*, a large-scale digital computer, and the savings and benefits derived by TCI from its use. The students then toured the IBM room and saw the *705* in operation.

The Auburn students then motored to Gorgas Steam Plant and were greeted by R. H. Copeland, supervisor of steam generation for Alabama Power Company, and B. R. Wall, superintendent of Gorgas Steam Plant. Prior to the inspection of the plant, the students were served lunch, compliments of the Alabama Power Company, after which they were divided into four groups and assigned guides. The inspection consisted of a tour through the older No. 2 Plant, coal handling equipment, boiler room, generator room, and switchboard. The tour was terminated with an inspection of the ultra modern No. 3 Plant consisting of two generators—combined capacity of 220,000 kva. Gorgas Steam Plant supplies a large portion of power to the Alabama Power Company system.

Several faculty members attended the inspection trip including Prof. A. T. Sprague, counselor, Student Branch of AIEE, Auburn; and Prof. W. F. Gray, counselor, Student Branch of AIEE, University of Alabama.

The day was climaxed for all the students by attending a joint meeting with the Alabama Section of AIEE at the Redmont Hotel. In addition to some 94 students, there were approximately 82 members and 9 visitors, giving a total attendance of approximately 185. The highlight of the program was the presentation of awards to winners of the

Courtesy Ragnar Thele

AT PRESENTATION of prize paper awards to University of Alabama student winners were (*left to right*): J. H. Wisdom, chairman, Student Branch Co-operation Committee, Alabama Section AIEE; J. H. Bryant and G. C. Waddell, joint second place winners; W. W. Clements, first place winner; and George Hoffman, chairman of the Alabama Section, who presented the awards to the students.

University of Alabama Student Branch paper competition held at the University of Alabama, January 8, 1959. They were as follows: first place, "A Short-Range Communications System," by W. W. Clements; second place, "A Unitized Self-Supporting Multiconductor Communications Cable," by J. H. Bryant and G. C. Waddell.

The speaker for the evening was M. E. Garity, power transmission department, General Electric Company, who spoke on "Extra-High Voltages of the Future."

Program for ASEE Electrical Division Meeting

Prof. A. V. Eastman of the University of Washington, chairman of the Electrical Division of the American Society for Engineering Education (ASEE), has announced details of the program arranged for the Annual Meeting of the ASEE to be held in Pittsburgh, Pa., June 15-19, 1959.

On Monday evening, June 15, at 8 p.m., there will be an informal discussion session to allow those electrical engineers in attendance to get acquainted and contribute their thoughts with regard to the future activities of the Division. Formal sessions have been arranged for Monday morning, for Tuesday and Thursday afternoons, and for all day Wednesday.

On Monday morning at 10 a.m., the theme of the session will be "Teaching Electrical Engineering Science Courses for Nonelectrical Students." Under chairmanship of Prof. W. B. Boast, secretary of the Division, the program will consist of the following papers:

"Introduction to Electrical Engineering Science: An Experimental Course for Nonelectricals," Prof. H. A. Foecke, Notre Dame University, Notre Dame, Ind.

"Linear System Analysis as a Foundation for Service Courses," Prof. J. G. Truxal, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

"Integration of Electrical Engineering into the Mechanical Engineering Curriculum," Prof. D. W. Ver Planck, Carnegie Institute of Technology, Pittsburgh, Pa.

On Tuesday afternoon at 2 p.m., Prof. A. V. Eastman, chairman of the Division, will serve as chairman of a session entitled "Follow-Up of the Workshop on Energy Conversion Held at MIT in 1957." The paper "An Integrated Lecture-Laboratory Program for Electrical Energy Conversion" will be presented by Prof. D. C. White and Prof. H. H. Woodson of Massachusetts Institute of Technology (MIT). An actual demonstration will be given of the "generalized machine" to illustrate its capabilities and to assist those who have, or are to receive, one of the devices in obtaining maximum benefit from the machine.

On Thursday afternoon at 2 p.m., the session will have the theme "Part Time Graduate Study in Electrical Engineering." Presiding will be Prof. J. H. Mulligan, Jr., vice-chairman of the Division. The four papers planned for the session are:

"The New York University Graduate Center at Bell Laboratories—A Progress Report on the First Two Years," Prof. S. S. Shamis, New York University, New York, N. Y.

"Part Time Graduate Programs in the New York Metropolitan Area," Dr. A. B. Giordano, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

"Part Time Graduate Programs in the San Francisco Bay Area," Dr. J. M. Pettit, Stanford University, Stanford, Calif.

"The Full Time Student—A Problem in Graduate Education Today," Dr. T. F. Jones, Jr., Purdue University, Lafayette, Ind.

On Wednesday, there will be a two-part program which will be held at the Research Laboratories of the Westinghouse Electric Corporation. In the morning, the following talks have been arranged:

"Ferrites and Ferro-Electricity," B. Davison, Case Institute of Technology

"Electro-Luminescence," F. E. Williams, General Electric Company

"The Maser," I. Wieder, Westinghouse Laboratories

In the afternoon, there will be a tour of the Research Laboratories with particular emphasis given to work being done in the areas discussed in the morning session.

The annual business meeting of the Electrical Division will be held at noon on Thursday. At the meeting, the election of officers will take place, and details of proposed future programs will be presented for consideration by the members of the Division. A Nominating Committee has been appointed to prepare recommendations for Division officers for the year 1959-1960. The chairman of the Committee is Dean J. Johnson, Wayne State University, Detroit, Mich. Other members of the Committee are Dean T. L. Martin and Prof. A. G. Conrad. Members are urged to send recommendations to the chairman of the Committee for consideration.

The Officers of the Division for 1958-59 are: Chairman, Prof. A. V. Eastman, University of Washington; Vice-Chairman, Prof. J. H. Mulligan, Jr., New York University; Secretary, Prof. W. B. Boast, Iowa State College; Representative on General Council (1957-59), Prof. Samuel Seely, Case Institute of Technology.

100% Club

Missouri School of Mines and Metallurgy

THE JOINT STUDENT BRANCH OF AIEE–IRE (Institute of Radio Engineers) at the Missouri School of Mines and Metallurgy was successful in reaching 100% membership of the seniors. There were 111 electrical engineers graduating this year, 37 in January. The Branch counselors are Jim Johnson for AIEE and Dr. Roger Nolte for IRE. Student chairman is Al Weinrich, and membership committee chairman is Jim Lawson. The electrical engineering department is the second largest department on the campus with an enrollment of 528.

Columbia Receives Gift for New Engineering Center

Columbia University has received a gift of $1.25 million from the Ambrose Monell Foundation of New York to be applied toward the cost of construction of the University's new Engineering Center, it was announced recently by President Grayson Kirk.

The gift has been made to establish the Ambrose Monell Library and to provide the Monell Student Center in the School of Engineering, President Kirk said. The facilities, he said, will constitute an important part of the first building of the prospective Engineering Center. The gift will memorialize the name of Ambrose Monell, who was graduated from the Columbia School of Engineering in 1896 with the degree of electrical engineer.

Mr. Monell was one of the leading industrialists of his day. Soon after gradua-

tion he achieved distinction in the field of engineering research. In 1902, when 28 years old, he became president of the International Nickel Company, Ltd. He became an outstanding industrial economist and administrator. His name became known throughout the world when it was adopted for the widely known alloy, "monel metal."

Three New ECPD Brochures To Guide Young Engineers

Three new brochures to guide young engineers during their first few years after graduation have been announced by the Training Committee of the Engineers' Council for Professional Development (ECPD).

This new literature is published in support of the "First Five Years" program of ECPD. It is designed to assist the young engineer in the critical early years of the postgraduate period when he will be finding his place in professional practice and will be endeavoring to establish his own professional goals.

"Your First Five Years," the first brochure, outlines the challenge to the young graduate embarking upon an engineering career, cites several guiding principles, and suggests a six-point professional development program consisting of the following: (1) Orientation and Training in Practice, (2) Continuing Education, (3) Professional Identification, (4) Responsible Citizenship, (5) Selected Reading, and (6) Personal Appraisal. Price: 10¢ each.

"Selected Reading for Young Engineers," the second item, has a perface which points out that: 'Two of the most important attributes the successful engineer must possess are first, the ability to deal with men and affairs, and second, the ability to read and absorb the written experience of others." This brochure contains a recommended reading list with suggestions in the fields of biography, travel, history, economics and sociology, psychology, philosophy, natural sciences, and general literature. Price: 15¢ each; quantity discount on request.

"Personal Appraisal Questionnaire" is the third publication. It is designed to aid the young engineer in evaluating his progress periodically so that he may effectively plan his steps in future professional development. This appraisal form identifies the many personal qualifications necessary and the numerous professional standard. to which a young engineer must adhere, if he is to achieve high standing in his chosen profession. Price 10¢ each.

All of these new publications are available as separate items or will be furnished with each purchase of the basic reference manual, "A Professional Guide for Young Engineers." This professional Guide contains the "Second Mile" papers of William E. Wickenden, and also includes a statement of the "Canons of Ethics for Engineers," and the "Faith of the Engineer." Total cost of the Guide and brochures is $1. Write to ECPD, 29 W. 39th St., New York 18, N. Y.

EMC-SMC Newsletter Reports on Earned Degrees

The following tabulation of degrees earned in institutions of higher learning is from the *Newsletter* issued jointly by the Engineering Manpower Commission (EMC) of Engineers Joint Council and the Scientific Manpower Commission (SMC).

Earned Degrees 1956-57 and 1957-58

	Bachelor		Master		Doctor	
	1956-57	1957-58	1956-57	1957-58	1956-57	1957-58
All fields	340,347	365,748	61,955	65,614	8,756	8,942
Agriculture	7,943	8,312	1,549	1,480	353	353
Biology	13,868	14,408	1,801	1,852	1,103	1,125
Mathematics	5,546	6,924	965	1,234	249	247
Physical sciences	12,934	14,352	2,704	3,034	1,674	1,655
Psychology	6,191	6,930	1,095	836	550	572
[SUBTOTALS]	46,482	50,926	8,114	8,436	3,929	3,952
Engineering	31,211	35,332	5,233	5,788	596	647
TOTALS	77,693	86,258	13,347 *	14,224	4,525	4,599

In a list in which everything is up, science registered a gain of 9.5% in bachelor's degrees; engineering, 13.1%. In all fields the gain was 7.5% compared with 1956-57. There was a gain of 322 in the number of master's degrees granted in science, but no significant change in doctorates. It may also be noted that biology barely retained its lead over the physical sciences in degrees granted at the bachelor's level. Th distribution of degrees in the physical sciences follows:

Physical Sciences—Earned Degrees 1957-58

	Bachelor	Master	Doctor
Astronomy	25	20	22
Chemistry	7,010	1,125	939
Meteorology	153	71	14
Physics	3,186	795	464
Earth Sciences	2,891	753	167
Unclassified	1,087	270	49
TOTALS	14,352	3,034	1,655

University of Illinois

A NEW USE for models is shown by Prof. W. Hay, University of Illinois, whose classes in railway civil engineering learn from this display how the same indication is presented by various types of signals. The quarter-inch scale display was presented to the University by the Union Switch and Signal Division of Westinghouse Air Brake Co. and C. E. Staples, company official and Illinois railway electrical engineering graduate in 1931, who made the model as a hobby. By setting a knob at the back of the base, any one of 10 standard signal rules is illustrated on the five different types of illuminated signals. Shown displayed is rule 290 "proceed at restricted speed."

Freshmen To Be Accepted at Columbia School of Engineering

Columbia University's School of Engineering will open its doors to freshmen next Fall for the first time since 1914.

A small group of highly qualified graduates of secondary schools will begin the new undergraduate program leading to a bachelor's degree in engineering. It will constitute the first freshman engineering class in 45 years.

Through the years the entering class is expected to grow to a maximum of 200.

Under the new program, members of the freshman engineering class will be eligible for intercollegiate athletics as well as other undergraduate extracurricular activities at Columbia.

Dr. J. R. Dunning, dean of the School of Engineering, said the new program has been under study for a number of years. He said that engineering first was taught in Columbia College before the Civil War, and later in the School of Mines. In 1914 engineering became essentially a graduate program, requiring 3 years of college courses and 2 years in engineering to obtain a degree.

Dean Duning said the new program will not disturb the present graduate program, but is "an exciting new development in engineering." He said the new plan is designed for qualified secondary school graduates who know what engineering is and feel a real affinity for it, yet it does not preclude changing to other careers, such as pure science, medicine, architecture, law, or business.

W. J. Hennessy, associate dean of the School of Engineering and chairman of the University committee planning the new undergraduate program, said the decision to admit first year engineering students was prompted by the School's intention to make fuller use of its facilities and to insure a steady flow of students into its graduate studies.

He emphasized that the School's long-standing concentration on "quality rather than quantity" will remain unchanged. The incoming freshmen, he said, will have to meet the most exacting admission requirements.

These requirements include superior class standing in an acceptable secondary school, above average on the College Entrance Examination Board tests; mathematics, including intermediate algebra, geometry, and trigonometry; physics and chemistry. Though not specifically required, 4 years of English, 3 years of a modern foreign language, and 3 years of history or social studies are desirable. Candidates for admission must take the College Board Scholastic Aptitude Test and three achievement tests—in English composition, advanced mathematics, and one elective subject.

Dean Hennessy stressed that "in no way does this (new program) represent a de-emphasis from the principle that engineers must be liberally educated."

Liberal arts courses such as contemporary civilization and humanities will be required of those enrolled in the new program.

In the first year, students will take mathematics, chemistry, graphics, physics, English, and development of Western institutions and social ideas. Second year courses include mathematics, physics, probability, mechanics, man in contemporary society, and European literature and philosophy.

In the second year, students who plan to become chemical engineers may take chemistry courses different from those given to students who plan to specialize in civil, electrical, industrial, mechanical, metallurgical, mineral, or mining engineering.

The third and fourth years provide rigorous training in the student's chosen branch of engineering.

Symposium on Applications of Economic Evaluation in Industry

The Engineering Economy Division of the American Society for Engineering Education (ASEE) and the Engineering Economy Research Committee of the American Institute of Industrial Engineers (AIIE) are co-sponsoring a 2-day symposium featuring industrial applications of engineering economy and related management techniques. The theme of this symposium is "Applications of Economic Evaluation in Industry." Topics covered include capital budgeting and project justification project post audit analysis, estimation of working capital requirements, effects of taxes on project justification, and the evaluation of uncertainty. Speakers include leading experts in these fields from both industry and academic institutions.

The symposium will be held at Hotel Webster Hall Saturday and Sunday, June 13-14, 1959. The registration fee is $25 with a special rate of $5 for academic personnel. Registrations and requests for further program details should be sent to M. K. Smith, American Telephone & Telegraph Co., Room 1104, 195 Broadway, New York 7, N. Y.

AEC Fellowships in Nuclear Science and Engineering

Some 183 young graduate students from 30 states, Puerto Rico, and Washington, D. C., have been offered special Atomic Energy Commission (AEC) fellowships for the study of nuclear science and engineering.

The Oak Ridge Institue of Nuclear Studies, which administers this fellowship program for the AEC, announced the selection of these outstanding students from more than 400 applicants.

Fellowship recipients may use this special AEC support for first-, intermediate-, or terminal-year graduate study, leading either to the master's or doctor's degree. More than 40 leading universities in the United States offering the required courses within the general field of nuclear science and engineering are co-operating in the program, and the fellowship appointees will be accepted into these schools for the 1959-60 academic year.

The fellowships were established by the AEC to encourage more grad students to pursue courses of study in this field, so as to help meet the nation's increasing demand for highly trained scientists and engineers in nuclear activities.

Science Students View Engineering Exhibit

As a highlight of its observance of National Engineers Week, Minneapolis-Honeywell Regulator Company invited 600 outstanding high school students from 80 Minnesota high schools to visit a multi-million-dollar exhibit of technological progress.

The 75 exhibits—covering 30,500 square feet of space in the Minneapolis Auditorium—featured a variety of Honeywell research and engineering activities in fields ranging from solar heating to "Space Age" research projects.

The students and their teachers were guests of Honeywell in advance of the firm's third annual "Engineers Night" program February 19. On hand for the three 2-hour student–teacher tours were 50 Honeywell scientists who served as tour guides and also answered student questions on career possibilities, educational requirements, etc., in all phases of science and engineering.

Students who participated were juniors and seniors who have displayed outstanding science and mathematic skills in high school. They were selected by their teachers on the basis of scholastic achievement.

Dr. Lachlan Reed, Honeywell's director of Industry–Education Relations, said that Honeywell technical experts were greatly impressed by the students' serious-minded approach to the entire program.

"These teen-agers displayed amazing knowledge about current scientific programs and problems," Dr. Reed added. "In fact, some of their questions forced our experts to get out their sliderules to provide the precise answers desired."

He pointed out that Honeywell long has worked with science students and teachers at both high school and college levels with such programs as teacher–student clinics, co-op work programs, fellowships, student career counseling, and has provided a variety of control devices and components for use in classroom activities.

WPI To Install Nuclear Reactor on Campus

Worcester Polytechnic Institute (WPI has contracted with the General Electric Atomic Power Equipment Department of San Jose, Calif., for installation of a nuclear reactor on the campus at a cost of $135,000.

It will be used for research, demonstration, and teaching in nuclear science and engineering, according to Pres. A. B. Bronwell. He also anounced Prof. L. C. Wilbur as director of the nuclear reactor facility. Construction of the one-thermal-kw pool training reactor will be completed by

August 1 in the northwest wing of the former WPI Washburn Shops. It will be enclosed by an aluminum lining in the building and 5-foot concrete walls and have other features incorporated for a high-level of safety, Pres. Bronwell said.

The reactor will be in the center of a pool of demineralized water, 8-feet square and 16 feet deep. The assembly will consist of a core, control and instrumentation systems, and a supporting structure. Heat from the core will be removed by natural circulation.

Notre Dame Students Present Papers to AIEE Section

Student members of the AIEE at the University of Notre Dame presented technical papers to members of the AIEE South Bend Section, the faculty, and fellow students at the annual Student Paper Contest at Notre Dame's College of Engineering on Tuesday evening, March 10, 1959. L. F. Stauder, faculty advisor for the Student Branch, arranged for the program.

The papers were 15 to 20 minutes in length and were judged on the basis of presentation, organization of facts, and originality. Contest winners and their subjects were as follows:

1. Robert Archey, a senior from Pittsfield, Mass., spoke on "Solar Batteries." This paper presented a brief history of solar batteries and described their principles of operation and present-day manufacturing techniques. The paper was extremely interesting and presentation was excellent.

2. Charles Olson, senior from Chicago, Ill., described "A Flux-Sensitive Magnetic Playback Head." The author called upon his experience at the Armour Research Foundation to describe the principles of a system of magnetic playback which permits an expansion of the ratio of playback time to recorded time by up to 40,000.

3. James Casey, senior from Charleston, W. Va., presented "Digital Computers Applied to the Design of Power Distribution Systems." This paper describes digital computers presently used to optimize performance and economy in power distribution systems.

Wayne Frost, chairman of the South Bend Section, presented the cash awards of $20 for first place to Mr. Archey, $10 for second place to Mr. Olson, and $5 for third place to Mr. Casey. In addition to the prize money, Mr. Archey received an expense paid trip to the District student paper competition at the University of Wisconsin in May.

Following the meeting, refreshments were served in the electrical engineering power laboratory, and members of the faculty guided AIEE members through the power and electronic laboratories.

Cornell Names New Dean of Engineering

D. R. Corson, professor of engineering physics and chairman of the Cornell physics department, has been named dean of the College of Engineering by the trustees of Cornell University, D. W. Malott, University President, announced recently.

Prof. Corson will succeed Dean S. C. Hollister on July 1 when the latter retires from the post which he has held for the past 22 years.

Courtesy of the South Bend Tribune

AT THE SOUTH BEND SECTION Student Paper Contest are: (*left to right*) James Olson, second place winner; Robert Archey, first place winner; L. F. Stauder, faculty advisor for the AIEE at Notre Dame; and James Casey, third place winner.

Joseph G. Tarboux Memorial Loan Fund

Announcement has been made that the Joseph G. Tarboux Memorial Loan Fund for engineering students has been established at the University of Michigan. Prof. Tarboux, who died February 6, 1959, was professor of electrical engineering at the University. Checks for this fund should be made payable to S. S. Attwood, Dean, College of Engineering, University of Michigan, Ann Arbor, Mich., with a letter of transmittal referring to this fund.

Short Course in Symmetrical Components

A 5-day short course in Symmetrical Components, designed for the practicing engineer as an up-to-date review or as an introduction of the technique to those with only an a-c circuit theory background, will be offered July 13-17 at Case Institute of Technology.

Directed by Dr. R. D. Chenoweth, assistant professor of electrical engineering, the course will cover the fundamentals of symmetrical and allied components. The program should be of particular interest to engineers interested in design of industrial systems and to public utilities technical representatives.

Fee for the 1-week course is $175. Additional information may be obtained from Dr. J. R. Hooper, Jr., Director of Special Programs, Case Institute of Technology, Cleveland 6, Ohio.

FEF Announces Wheelabrator Fellowship Winners

The Board of Awards of the Foundry Educational Foundation (FEF) has announced the presentation of five $1,500 Wheelabrator Graduate Fellowships for 1959.

The Wheelabrator Foundation in cooperation with the FEF established the Wheelabrator Foundry Educational Program in 1958. The program is to provide 50 Fellowships valued at $1,500 each during a 10-year period.

The 5 young engineers selected from 31 outstanding applicants will begin their graduate studies this coming September.

R. G. Liptai, St. Louis, Mo., will do his graduate work in mechanical engineering at the Missouri School of Mines. He receives his bachelor's degree from Missouri School of Mines this June. Mr. Liptai is a previous FEF Scholarship Winner.

E. J. Poirier of Medford, Mass., receives a degree in chemical engineering from Northeastern in June. He will begin his graduate work in engineering at Massachsetts Institute of Technology (MIT) in September.

J. H. Steele, Blacksburg, Va., graduates from Virginia Polytechnical Institute (VPI) in metallurgical engineering this June. He will do his graduate work in the same field at VPI. Mr. Steele held three

separate scholarships as an undegraduate, FEF, ASM, and State of Virginia awards. T. S. Piwonka of Cleveland, Ohio, will begin his graduate work in metallurgy at Case Institute after receiving his bachelor's degree in metallurgical engineering from the same institution this June. He held a Leonard Case Honor Scholarship for 4 years and an FEF Scholarship for 3 years as an undergaduate.

C. A. Rowe of Coraopolis, Pa., graduates in metallurgy from MIT this June and will begin his graduate work in the same field at MIT in September. Mr. Rowe held FEF Scholarships for 3 years as an undergraduate and a Rovensky Scholarship for 4 years.

These Fellowships are sponsored by a $100,000 grant made by the Wheelabrator Foundation to the FEF. The program is open to men who are not over 28 years of age on the day of application and who are either a senior undergraduate or graduate student registered with the FEF, or a returning veteran who was either registered with the FEF or been employed in the foundry or an allied industry. Also eligible are otherwise qualified young men who are currently employed in the foundry industry.

Applications are now being accepted from those desiring to begin study in September of 1960. The deadline for applications is December 31, 1959. Application forms and further information can be obtained from the Foundry Educational Foundation, Terminal Tower Building, Cleveland 13, Ohio.

Lehigh Receives Grant for Research

The Institue of Research of Lehigh University has been awarded $45,020 to carry on research and design work in the field of active networks in the department of electrical engineering.

In announcing receipt of the contract, Dr. H. A. Neville, provost and vice-president, said it is sponsored by the U.S. Army Signal Corps. It is aimed at analyzing and developing vacuum-tube and transistor networks suitable for Signal Corps Communication Systems.

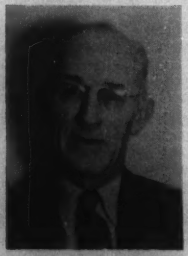
The project is under the general supervision of Prof. J. J. Karakash, head of the department of electrical engineering. The technical work will be directed by Dr. A. I. Larky, research assistant professor of electrical engineering.

AIEE FELLOWS ELECTED

Board of Directors Meeting, February 6, 1959

Henri Busignies (M '56), president, ITT Laboratories, Nutley, N. J., has been transferred to the grade of Fellow in the AIEE ". . . for contributions in the fields of electronic direction finding, air navigation, radar, and radio communications." Mr. Busignies, born in Sceaux, France, on December 29, 1905, has been with International Telephone & Telegraph Corporation (ITT) for 30 years. Inventor, scientist, and a leading authority on direction finders, he is the holder of more than 100 patents in the aerial navigation, radar, and communication fields. He is known as the inventor of the world's first automatic direction finder for aircraft, and for having directed large research and development programs, among them the TACAN radio navigation system. His contributions to the World War II effort included the development of a shore-based direction finding system, known as "Huff-Duff," which proved a vital factor in the war on enemy submarines. In recognition of these services, he was awarded the U. S. Navy Certificate of Commendation for outstanding services to the U. S. Navy, and the Presidential Certificate of Merit for his activities with the National Defense Research Council. An honorary degree of doctor of science was conferred upon him by the Newark College of Engineering in 1958. Mr. Busignies received his degree in electrical engineering in Paris in 1926. He joined the ITT System in 1928 as an engineer with the Paris laboratories and for the next 12 years carried on research and development in direction finders, instrument landing, and early radar designs. His automatic direction finder, first tested in a dramatic flight from Paris to the Isle of Reunion off Madagascar, was successfully demonstrated in the United States in 1937. Since 1941, when he participated in the founding of ITT Laboratories (formerly Federal Telecommunication Laboratories), Mr. Busignies has had a major role in the growth of the company's research and development activities. He became a technical director of the Laboratories in 1949, vice president and member of the management advisory board in 1953, and executive vice-president in 1954. He was named president on May 24, 1956.

Fabian Bachrach
Henri Busignies



R. D. Elliott

Carl W. Diehl* (AM '34, M '39), consulting engineer, Westinghouse Electric Corporation, Sharon, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the design of equipment and procedures for testing distribution and power transformers." Mr. Diehl was born in Pittsburgh, Pa., on January 29, 1889. He joined Westinghouse in 1925 as testing engineer, and served with the company throughout his engineering career. His major attainments were (1) as works engineer in charge of planning for two major expansions to provide modern and increased facilities for manufacturing and testing distribution transformers; and (2) as works engineer in charge of design and construction of a Power Transformer Test Center, with a very large anechoic room for noise measurement, special generators with capacitor banks, and impulse generators. Transformers as large as 360,000 kva have been tested in this new test center. He was named consulting engineer in 1956. Mr. Diehl served as chairman of the Sharon Section of the Institute in 1939, and as a member of the AIEE Instrument Transformer Subcommittee during 1939.

Robert Drane Elliott (AM '38, M '44), vice-president and consulting engineer, Dallas Power & Light Co. (DP&L), Dallas, Texas, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the design and construction of large electric utility systems." Mr. Elliott was born on May 19, 1894, in Corsicana, Texas. He attended Texas A&M, receiving his degree of B.S. in E.E. in 1917. He served in the U. S. Army during World War I. He began his career in 1920 with DP&L as a field engineer. He held various positions in the engineering department of the company, rising to chief engineer in 1942; and in 1956, to vice-president and consulting engineer as executive consultant to management in engineering problems relating to company property. Beginning in 1936, Mr. Elliott was responsible for the early application of large quantities of capacitors on the 4-kv distribution system, continuing in 1937 the application of capacitors on the 13-kv distribution system and with additional capacitors being installed on the downtown network system in 1591. In 1937, he was responsible for the large-scale conversion of the distribution sys-

*We have been informed that Mr. Diehl died in December 1958, after a somewhat lengthy illness.

J. L. Fuller

Romaine-Skelton

W. R. Hewlett

P. H. Light

tem from 4 kv to 13 kv. This also started joint use agreements with the telephone company at 13 kv in the southwest. In 1954, he was responsible for the design and construction of the first 480Y/277-volt spot network in the DP&L underground network system which has now expanded to several such networks. Beginning in 1938, he assumed charge for continuing the design and construction of the 69-kv system, resulting in the transmission loop being completed around the City of Dallas in 1952. He started the conversion of the 69-kv transmission system to 138 kv in 1956. He also was responsible for working out joint use agreements at 69 kv with the telephone company, which enabled DP&L to extend 69-kv transmission lines into residential areas. From 1942 to 1956, he was in charge of engineering design and construction of a total of 12 additions to generating stations, being completed by 1958, totaling 838,000 kw net, raising the capacity of DP&L's system from 118,000 kw to 956,000 kw. Mr. Elliott has served on various committees of the North Texas Section of AIEE. For several years he served on the Edison Electric Institute Transformer Advisory Committee. Mr. Elliott is a registered professional engineer in the State of Texas. He is also a member of Eta Kappa Nu, Dallas Electric Club, and Engineers Club of Dallas.

John Lawrence Fuller (AM '37, M '45), director of engineering, Marquette Division, Curtiss-Wright Corporation, Cleveland, Ohio, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to design, controls, and testing of electrical power equipment." Mr. Fuller was born in Cleveland on November 11, 1913. He received the B.S. degree in E.E. from Case Institute of Technology in 1936. After graduation, he joined the Reliance Electric & Engineering Company in Cleveland in the general training course for a period of 9 months. For the next 3 years, he was junior engineer concerned with electrical and mechanical design of a-c and d-c industrial motors. This period also involved engineering responsibility for the development of the Reliance "VS Drive" including rotating and control equipment and engineering of initial applications. He was also responsible for the development of an electric speed indicator. In 1940, after a period as night engineer, he supervised design, relocation, and reconstruction of production test facilities for the complete line of rotating equipment. In 1941, he was promoted to experimental engineer, and in 1945, he became electrical development engineer. Two years later, he became manager, large motors engineering, with responsibility for all mechanical and electrical engineering associated with a-c and d-c equipment in a range of approximately 15 to 500 hp. In 1951, he became manager, research and technical services. Of interest was the development of a novel and effective standby power system for the Savannah River Project using inherent characteristics instead of control to accomplish the ultimate in reliability. In 1955, he assumed his present position as director of engineering with the Marquette Division. Mr. Fuller is a member of the Cleveland Engineering Society, American Management Association, Tau Beta Pi, Sigma Xi, and Eta Kappa Nu. He is the author of several technical papers and has obtained several patents in the field of windings and control systems. He is a registered professional engineer in the State of Ohio. A past chairman of the Cleveland Section, he has served on the following AIEE Committees: Instruments and Measurements (1943-48); Rotating Machinery (1947-53); Sections (1953-55); General Industry Applications (1954-55, 1957-58); and Administration Department (1956-57). He has also been secretary of District No. 2 and of District No. 11 when newly formed.

William R. Hewlett (AM '40, M '47), executive vice-president, Hewlett-Packard Company, Palo Alto, Calif., has been transferred to the grade of Fellow in the AIEE ". . . for technical and administrative achievements in the development and manufacture of precision electrical measuring equipment." Mr. Hewlett was born in Ann Arbor, Mich., on May 20, 1913. He received the A.B. degree in 1934 from Stanford University and the M.S. degree in 1936 from the Massachusetts Institute of Technology. During 1936-38, he was engaged in electromedical research in Palo Alto. He was awarded the E.E. degree in 1939 from Stanford. With David Packard, he organized the Hewlett-Packard Company in 1939. In 1942, Mr. Hewlett was called to active duty in the U.S. Army and was assigned to the Technical Division of the Office of the Chief Signal Officer in Washington, D.C., for the next 3 years. He was transferred then to the New Development Division of the War Department's Special Staff where he served as head of the Electronics Section. In December 1945, he returned to the Hewlett-Packard Company which he now serves as executive vice-president and director. His other directorships include: Dymec, chairman of the board since 1957, president, 1956-7; Hexcell Products, Inc., director since 1956; Mills College, director since 1958; Palo Alto-Stanford Medical Center, director since 1956, president, 1958; Stanford Hospital, board of governors since 1958; Palo Alto-Stanford Community Chest, president, 1956-57. Mr. Hewlett is a member of Sigma Xi and Eta Kappa Nu. He is a fellow of the Institute of Radio Engineers (IRE) and served as president of the IRE in 1954. He was chairman of the San Francisco Council of the West Coast Electronic Manufacturers' Association in 1948. He has served on the Scientific Advisory Council of the U.S. Army Electronic Proving Ground since 1956. Mr. Hewlett is co-author of several technical articles and holds patents on rc oscillators and others in the field of electronics. He served on the AIEE Television Broadcasting Systems Committee (1949-57).

Philip H. Light (AM '36, M '43), electric utility application engineer, General Electric Company, Schenectady, N. Y., has been transferred to the grade of Fellow in the AIEE " . . . for contributions to electric power transmission." Mr. Light was born in Des Moines, Iowa, January 20, 1910. He received the B.S. degree in E.E. from Iowa State College in 1935. Shortly thereafter he joined the General Electric Company on the test program. In 1937, he transferred to the Power Generation and Transmission Section of the central station engineering department, and a year later was transferred to the Analytical Section of the same department, where he studied system overvoltages—their causes and means of control. During 1939-40, he worked, on a temporary exchange basis, in the operating department of Georgia Power Company. He returned to the central station engineering department of General Electric Company in 1940 specializing in application techniques of system protection equipment. In 1946, he was appointed sponsor engineer in the Electric Utility Section with headquarters responsibility for application of General Electric apparatus equipment on utility systems in the northwestern part of the United States. In 1955, he became manager

L. R. Quarles

J. F. Rader

W. E. Shoupp

of the Electric Utility Engineering Unit of the Systems Engineering Section responsible for headquarters application engineering of equipment for the electric utility industry. In 1958, he rejoined the Electric Utility Engineering Section. Mr. Light has presented numerous paper before Section, District, and National AIEE meetings, and industry association meetings. He holds several patents in the field of system protection. Mr. Light is a registered professional engineer in New York State, a member of Eta Kappa Nu, Tau Beta Pi, and Phi Kappa Phi. He has an active interest in the local AIEE, serving as chairman of the Schenectady Section, 1945-46, and is director, National Relations Schenectady Section. He has served on the National Program Committee and is a member of the District Nominating Committee, Empire District 1958-61. Mr. Light served on the AIEE Membership Committee (1946-48) and Technical Program Committee (1948-50).

Lawrence Reginald Quarles (M '45), dean, School of Engineering, University of Virginia, Charlottesville, Va., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to engineering education and nuclear engineering." Mr. Quarles was born in Charlottesville, Va., on January 26, 1908. Following graduation with the degree of B.S.E. from the University of Virginia in 1929, he entered the student engineering training course of Westinghouse Electric & Manufacturing Company. The following year he joined the Research Laboratory of Westinghouse where he worked on the development of gas-filled tubes. He returned to the University of Virginia for graduate study in physics in 1932. After receiving the Ph.D. degree in 1935, he remained at Virginia as a member of the staff in electrical engineering. During the war period 1941-45, he was director of War Training Courses for the University and also served as research physicist on electronic development projects of the University. During 1950-51, he was on leave from the University and served as section head, homogeneous reactor controls, at Oak Ridge National Laboratory. Although he returned to the University of Virginia in 1951, he has continued active consultation in nuclear energy with Oak Ridge National Laboratory and the Atomic Energy Commission. He has been professor of electrical engineering at Virginia since 1947 and dean of engineering since 1955. He has initiated the development of degree programs in electronics and nuclear engineering at the University of Virginia. He is a registered professional engineer in the State of Virginia and a member of the Virginia Society of Professional Engineers. He is a member of Tau Beta Pi, Sigma Xi, and Eta Kappa Nu. He is a Fellow of the Institute of Radio Engineers, a member of the Board of Directors of the American Nuclear Society, and a member of the American Society for Engineering Education. He served as a director of the Virginia Section of the Institute, 1948-50.

John Frank Rader (M '40), vice-president and chief engineer, South Carolina Electric & Gas Company, Columbia, S.C., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to design, construction, and operation of an electric utility system." Mr. Rader was born in Warwick, N. Y., on August 21, 1897. He graduated from Lafayette College in 1918. Mr. Rader started his engineering career with the Metropolitan Edison Company in Reading, Pa., inventorying and pricing substation equipment for valuation. He did drafting and designing of electric substations and electric plant equipment and was sent to the Central Vermont Hydro Corporation near Rutland, Vt., to superintend the construction of such installations. Early in 1920, Mr. Rader was transferred to Binghamton Light, Heat, and Power Company, Binghamton, N. Y., as superintendent of electric construction and maintenance. In the Fall of 1925, he was sent to Columbia, S.C., with the Broad River Power Company as electrical engineer in charge of design and construction of substations and the operation of electric equipment in the plants and substations. He was frequently promoted to general superintendent and then to chief engineer. Upon the formation and incorporation of South Carolina Generating Company, he was elected director of that company and subsequently he was elected vice-president. He was recently elected vice-president of the parent company—South Carolina Electric & Gas Company. Mr. Rader is a registered professional engineer in the State of South Carolina.

William Earl Shoupp* (M '48), technical director, Atomic Power Department, Westinghouse Electric Corporation, Pittsburgh, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the technology of nuclear power generation and submarine propulsion." Dr. Shoupp was born in Troy, Ohio, on October 5, 1908. He received a B.A. degree in physics in 1931 from Miami University, Oxford, Ohio. He served as graduate assistant and instructor in physics at the University of Illinois, receiving his M.A. in 1933 and Ph.D. in 1937. After remaining another year as instructor at Illinois, he joined Westinghouse as a research fellow in the fall of 1938. In 1941, he became a research engineer in the Laboratory at East Pittsburgh, Pa., and was made manager of the electronics and nuclear physics department at the Research Laboratory in 1943. In 1948, Dr. Shoupp was transferred to the Westinghouse Atomic Power Division located at the old Bettis Airport. Operating under an Atomic Energy Commission contract, the Atomic Power Division had as its first job, the development of a power plant for the first atomic powered submarine, the *USS Nautilus*. During the period 1949 to 1955, Dr. Shoupp held positions with the Atomic Power Division of director of research, director of development, and assistant manager—development. In August 1955, he was appointed technical director of the newly formed Atomic Power Department. During his career with Westinghouse, Dr. Shoupp has distinguished himself as a research physicist in the field of nuclear physics and associated atomic power problems, radar and ultra-high-frequency phenomena, and in electronics. His outstanding research contribution since joining Westinghouse has been work which culminated in the discovery of photo-fission. In 1949, Dr. Shoupp was named "Man of the Year in Science" by the Pittsburgh Junior Chamber of Commerce and in 1953, was awarded the Westinghouse Order of Merit. In 1956, he received an honorary doctor of science degree from Miami University. Dr. Shoupp has written many articles for scientific publication. He is a member of the American Physical Society, Pittsburgh Physical Society, Institute of Radio Engineers, American Society of Mechanical Engineers, and American Nuclear Society, as well as several honorary scientific societies. He was a member of the AIEE Nucleonics Committee (1949–56).

*Dr. Shoupp's transfer to the grade of Fellow was voted on at the Board of Directors Meeting on December 11, 1958.

AIEE PERSONALITIES

D. E. Argo (AM '47), Western regional manager, A. B. Chance Company, has been promoted to regional vice-president. In his new position, Mr. Argo will be in charge of all company operations in eight western states including the A. B. Chance Company's manufacturing plant and sales ServiCenter in San Francisco, Calif.

N. P. Bashor (AM '55), director of the Electrical Controls Division of W. F. & John Barnes Company, has been appointed chairman of the Electrical Standards Committee of the National Machine Tool Builders' Association. **N. A. Anderson** (AM '47), chief electrical engineer, Grinding Machine Division, Norton Committee, is one of the new appointees to the Electrical Standards Committee.

A. S. C. Chong (AFFIL '55), electrical engineer for U. S. Corps of Engineers, Honolulu District, has joined the staff of Park & Yee, Engineers and Architects, Honolulu, as head of the new Electrical Division.

E. M. Coan (M '58), has been named development engineering department head, and J. F. Reeves (AM '44) has been named systems analysis department head at Vitro Laboratories, West Orange, N. J., a division of Vitro Corporation of America.

R. C. Day (AM '52), associate engineer, has been appointed to the position of staff engineer in the Endicott Product Development Laboratory of International Business Machines Corporation, Endicott, N. Y.

W. R. Fraser (AM '42) has been appointed to the newly established position of consulting engineer—product design, for engineering and designing of complex broadcast transmitters in the General Electric Company's technical products department. He was formerly a product-design engineer.

Philip Granick (AM '52) has been appointed general sales manager of Fisher-Pierce Co. of South Braintree, Mass., and its affiliate, Sigma Instruments, Inc.

S. N. Golembe (AM '43, M '49), executive vice-president, Power Sources, Inc., Burlington, Mass., had been elected president.

J. R. Harkness (AM '37), vice-president and general manager of the Electronics Division, Byron Jackson Division of Borg-Warner Corp., has been appointed to the new post of electronics manager at Bendix-Pacific Division of Bendix Aviation Corporation.

T. A. Hauge (AM '54), project engineer of special electronic devices at Maico Electronics, Inc., has joined the engineering staff of Control Data Corporation, Minneapolis, Minn., as senior electrical engineer.

P. L. Howard (M '50), director of technical operations, Yardney Electric Corp., has been named assistant vice-president in charge of technical field operations.

M. H. Kebby (AM '55), product development manager, Lenkurt Electric Company, San Carlos, Calif., has been named chief engineer of the Commercial Products Division of the Company.

Bernard Litman, (AM '42, M '48) has been appointed assistant chief engineer for research, and **Wen Tsing Chow** (AM '43, M '52) has been appointed assistant chief engineer, missile guidance, at Arma Division, American Bosch Arma Corporation. Dr. Litman was formerly project head, inertial equipment. Mr. Chow was project head, computer and systems.

B. J. O'Neil (AM '47), chief engineer for Magnetic Amplifiers, Inc., New York, N. Y., has been named to the newly created post of vice-president in charge of engineering.

R. H. Porterfield (AM '44, M '51), manager of the Hartford (Conn.) district, Allis-Chalmers Manufacturing Company, has been appointed manager, industrial sales, New York district.

C. M. Roberts (AM '57) has been elected vice-president of The Datics Corporation, Fort Worth, Tex. As vice-president and chief of operations, he is responsible for the maintenance and procurement of all physical equipment and supplies, and for production of all work in the areas of data preparation and machine processing.

F. M. Scott (AM '41, M '50), sales representative in the Chicago (Ill.) district of Allis-Chalmers Manufacturing Company, has been appointed manager of utility sales in the Chicago area. **J. N. Banky** (AM '44, M '54) has been named manager, heavy industrial sales.

Thomas Hollingsworth (AM '49), manager of product planning, Westinghouse Electric Corporation, will direct all market functions including sales, advertising, and product planning for Electrical Engineers Equipment Company, Melrose Park, Ill.

B. C. Biega (AM '50, M '57), engineer, specialty transformer department, General Electric Company, has been appointed assistant sales manager by the Precision Transformer Corporation, Chicago, Ill. Mr. Biega has served as chairman of the AIEE Fort Wayne Section. He is a member of the Electric Power Distribution for Industrial Plants Subcommittee.

G. H. Brown (M '41, F '48), chief engineer, industrial electronic products, Radio Corporation of America (RCA), has been elected vice-president, engineering, of RCA. Dr. Brown will be responsible for the direction of the corporate engineering staff including operations engineering, product engineering, and the RCA Frequency Bureau. He is a member of the AIEE Television and Aural Broadcasting Systems Committee (1949-59) and Communication Theory Committee (1955-59).

C. R. Burrows (AM '26, F '45), vice-president for engineering, Ford Instrument Co., division of Sperry Rand Corp., has accepted a position as vice-president and director of engineering of Radiation, Inc., Melbourne, Fla. Internationally known as an expert on electromagnetic wave propagation, Dr. Burrows is a fellow of the Institute of Radio Engineers and American Physical Society, and a member of the American Rocket Society, American Ordnance Association, Sigma Xi, Tau Beta Pi, and Eta Kappa Nu. Dr. Burrows served on the following AIEE Committees: Basic Sciences (1947-52); Research (1947-55, 1956-59); and Education (1958-59).

C. C. Chambers (AM '35, F '51), vice-president in charge of engineering affairs, University of Pennsylvania, Philadelphia, Pa., has become chairman of the ASA sectional committee C61—electric and magnetic magnitudes and units. Dr. Chambers represents the American Association for the Advancement of Science on this committee. **K. N. Mathese** (AM '36, M '43), insulation systems engineer, general engineering laboratory, General Electric Company, Schenectady, N. Y., has become vice-president of ASA sectional committee C59—electrical insulating materials. Mr. Mathes represents the AIEE on the committee. Dr. Chambers served as liaison representative on the AIEE Standards Committee (1951-55). Mr. Mathes is a member of the AIEE Electrical Insulation Committee (1955-59, chairman 1958-59) and Science and Electronics Division (1958-59).

J. B. Coleman (AM '25, F '56), manager of the Radio Corporation of America (RCA) BMEWS (Ballistic Missile Early Warning System) program for the U. S. Air Force, has been appointed as administrator, high-power transmitters, for RCA defense electronic products. Mr. Coleman has served on the following AIEE Committees: Communication (1937-49); Air Transportation (1945-48); Television Broadcasting Systems (1949-50 chairman); Television and Aural Broadcasting Systems (1950-59, chairman 1950-52); Technical Program (1949-50); Standards (1949-50); Communication Division (1949-52); Award of Institute Prizes (1952-53); Special Communication Applications (1953-56); and Technical Operations (1954-56).

Rudolph Feldt (M '46), vice-president, Industrial Products Division, International Telephone & Telegraph Company, has been named to head Rohde & Schwarz Sales Co., Inc., Passaic, N. J. Dr. Feldt has served on the following AIEE Committees: Electronics (1947-59), Instruments and Measurements (1950-55), Special Instruments and Auxiliary Apparatus (1956-59), and Electronic and High-Frequency Instruments (1956-59).

J. F. Ferrante (AM '50, M '58), has been promoted to the vice-presidency of Tobe Deutschmann Corporation, Norwood, Mass. Mr. Ferrante has been with the firm for 9 years.

F. J. Gaffney (AM '37), vice-president for engineering, Teleregister Corp., has been appointed executive vice-president and general manager of FXR, Inc., Woodside, N. Y. Mr. Gaffney served on the AIEE Instruments and Measurements Committee (1947-52).

A. R. Gruehr (M '30, F '57), head of the department of economics and history at the Polytechnic Institute of Brooklyn, has been elected president of the New York State Society of Professional Engineers. A leading figure in the drive for the improvement of the teaching of mathematics and science in the high schools, Dr. Gruehr is a member of the National Committee of the Society and chairman of the committee on Engineering Preparation. **J. A. Mathes** (AM '25, M '34), Consolidated Edison Company of New York, Inc., was elected financial secretary. Dr. Gruehr is a member of the AIEE Public Relations Committee (1955-59).

W. T. Harding (AM '44, M '53), formerly civilian head of the Aeronautical Accessories Laboratory at Wright Air Development Center, has been retained by Consolidated Diesel Electric Corporation as a long-range consultant. Mr. Harding served on the AIEE Air Transportation Committee (1946-51, 1954-57).

H. S. Holbrook (AM '19, F '31), consulting engineer on transformers, British Thomson-Houston Co., Ltd., (BTH), Rugby, England, has retired after 48 years of service with the company. Mr. Holbrook joined BTH in 1910 and has been engaged on the design of transformers since 1911. He was appointed chief transformer engineer in 1929. He relinquished the managership of the BTH transformer engineering department in August 1950, on being appointed consulting engineer on transformers.

M. J. Kelly (M '26, F '31), retiring chairman and former president of Bell Telephone Laboratories, has been engaged by International Business Machines Corporation as a consultant on research and engineering matters. Dr. Kelly has had a distinguished career in industrial research and as an advisor to government agencies. Recently he received the 1958 James Forrestal Medal of the National Security Industrial Association and the 1959 John Fritz Medal. Dr. Kelly has served on numerous AIEE Committees.

L. C. Schaefer (AM '39, M '58), engineering manager of the Westinghouse Electric Corporation Small Motor Division in Lima, Ohio, has joined the Century Electric Company, St. Louis, Mo., as manager of engineering. Mr. Schaefer served on the AIEE Rotating Machinery Committee (1957-58).

B. H. Schultz (AM '49, M '55) chief engineer, capacitors and regulators, Line Material Industries (L-M) McGraw-Edison Company, has been appointed manager of engineering, Kyle Products, Mr. Schultz joined L-M in 1947. **H. C. Stone** (AM '50), has been promoted to assume the duties of chief engineer, capacitors and regulators. Mr. Schultz is a member of the AIEE Transmission and Distribution Committee (1958-59).

J. T. Lusignan (AM '27, F '50), executive engineer, Ohio Brass Company (O-B), Mansfield, Ohio, has been elected vice-president—engineering and will continue to head all O-B engineering activities. Mr. Lusignan has been with O-B since 1930, first serving in the power utilities department in Mansfield and later as an electrical engineer in Barberton. He became executive engineer of O-B in 1938. Mr. Lusignan has served on the following AIEE Committees: Transmission and Distribution (1936-59), Instruments and Measurements (1943-55), Standards (1942-50) Science and Electronics Division (1951-55), and Safety (1951-55).

F. B. Bramhall (AM '31, F '44) has retired from the Western Union Telegraph Company, New York, N. Y., after 38 years of company service. Mr. Bramhall, who joined Western Union in 1920, received the 1957 F. E. d'Humy Award in recognition of his "contributions to the art of frequency-modulated carrier telecommunication and for technical direction leading to its wide adoption." He was served West ern Union as transmission research engineer, transmission planning engineer, and automation engineer, and as chairman of Western Union's Committee on Technical Publication, which is responsible for the production of the *Western Union Technical Review*. He is a senior member of the Institute of Radio Engineers, and has been active in the Association of American Railways, the Electronics Industries Association, and on several AIEE Committees. Mr. Bramhall recently joined Lenkurt Electric Company as an engineering consultant.

R. H. Horner (AM '50), formerly associated with The Wakefield Company of Vermilion in sales and field engineering capacities, has joined the military avionics department, Goodyear Aircraft Corporation's Engineering Division, Akron, Ohio.

D. R. Hull (M '48), vice-president of Raytheon Manufacturing Company, and currently serving as president of the Electronic Industries Association, has been elected to the board of directors of the Mycalex Corporation of America.

OBITUARIES

Samuel Northrup Castle (AM '08, M '13, F '18, Member for Life), Honolulu, Hawaii, died recently at the age of 79. Mr. Castle was born on February 6, 1880, in Honolulu. He received his B.A. degree from Harvard University in 1901, and was engaged in graduate work from 1902 to 1904 at Cornell University. In 1905, Mr. Castle was employed by the Westinghouse Machine Company. During his engineering career, which lasted almost 40 years, he was associated with numerous firms, including Westinghouse, Allis-Chalmers Manufacturing Company, General Electric Company, Honolulu Rapid Transit Company, Castle and Cooke, Hawaiian Pineapple Company, Advertising Publishing Company, and Radio Station KGU. Mr. Castle was a fellow of the American Association for the Advancement of Science, American Society of Mechanical Engineers (ASME), American Institute of Chemical Engineers, and a life member of the American Society of Civil Engineers. He was the recipient of the 75th anniversary medal of the ASME in 1955.

William David Dishner (AM '46, M '52), superintendent, Johnson City Power Board, Johnson City, Tenn., died recently. Mr. Dishner was born December 13, 1908, in Bristol, Tenn. He graduated from the University of Tennessee in 1932 with a B.S. degree in E.E. He was a member of Tau Beta Pi. After graduation, he was employed by the East Tennessee Light & Power Company. In 1945, he became associated with the Tennessee Eastman Corporation, Kingsport, Tenn. He joined the Johnson City Power Board in 1948 as superintendent. Mr. Dishner was secretary-treasurer of the Upper East Tennessee Subsection of the AIEE.

Francis Evarts Fairman, Jr. (M '41, F '51), consultant, Transformer Division, General Electric Company, Pittsfield, Mass., died recently. Mr. Fairman was born in Pittsburgh, Pa., on October 15, 1899. He received the B.S. degree from the U.S. Naval Academy, Annapolis, Md., in 1921. He joined the General Electric Company in 1923 as a requisition engineer in the Baltimore, Md., works. He was a junior electrical engineer with the Pennsylvania Water & Power Company during 1925, and then returned to his former position at General Electric. From 1945 to 1949, Mr. Fairman was vice-president of the Food Machinery and Chemical Corporation and general manager of its Peerless Pump Division. In 1949, he returned to General Electric, becoming manager of sales for the Transformer and Allied Products Division. He was named general sales manager of the Large Apparatus Division in 1950, general manager of the Transformer Division in 1951, and a vice-president of the company in 1953. Mr. Fairman was a registered professional engineer in the States of Massachusetts and California, and was a member of the Association of Iron and Steel Engineers.

Harry Barnes Gear (AM '01, M '13, F '20), retired, of Chicago, Ill., died recently at the age of 87. Born in Marietta, Ohio, on March 6, 1872, he received his B.A. degree from Marietta College in 1892 and an M.E. degree from Cornell University in 1895. Joining Chicago Edison Company in 1895 in the meter department, he progressed to engineer of distribution, becoming vice-president of Commonwealth Edison Company in 1936, in charge of engineering and operating. Mr. Gear retired in 1944 after nearly 50 years of service with Edison. In 1905, with P. F. Williams, G & W Electric Specialty Company was formed to manufacture cable potheads and other distribution system equipment based on his inventions. His interest in this company was terminated in 1935. In 1911, he was co-author of the first book written on "Electric Central Station Distribution Systems"; the book

was rewritten several times and later appeared entitled "Electric Service Distribution Systems." It was used as a text book in many electrical engineering schools. For many editions, he edited the "Distribution Systems" section of the Standard Handbook for Electrical Engineers. Mr. Gear was a past president of the Western Society of Engineers. He was awarded many prizes and honors as an engineer and has been listed in "Who's Who" for many years. He was active on many AIEE Committees including Safety Codes, Standards, Lamme Medal, Technical Program, Edison Medal, Washington Award Commission, Institute Policy, Planning and Co-ordination, and Marsten Medal Board of Award.

Carl Mitchell Gilt (AM '21, M '26, F '35, Member for Life), retired, of Princeton, N. J., died recently at the age of 67. Mr. Gilt had been employed by Consolidated Edison Company of New York for more than 30 years. He had served the company as inside plant engineer and outside plant engineer, and he held the position of assistant purchasing agent at the time of his retirement in 1957. Mr. Gilt was a past president of the New York State Society of Professional Engineers. He was a member of the American Society for Testing Materials and had been active in committee work of the Edison Electric Institute and the American Standards Association. Mr. Gilt served on the following Institute Committees: Electrical Machinery, Standards, Technical Program, and Power Transmission and Distribution.

Carl Kinsley (AM '97, F '35, Member for Life), consulting engineer, Falls Church, Va., died recently. Mr. Kinsley was born in Lansing, Mich., on November 25, 1870. He received the A.B. degree from Oberlin College, and the E.E. degree from Cornell University. He was a member of the faculty of the University of Chicago from 1894 to 1917. During World War I, he served as Major in the U. S. Army. From 1919 to 1928, he worked as consulting engineer for various firms, and in 1928, he joined U. S. Steel Corporation as consulting engineer. Mr. Kinsley held several United States patents and was the author of numerous technical articles. He was a fellow of the American Association for the Advancement of Science and the American Physical Society and a member of the Institute of Radio Engineers. He was a member of the AIEE Electrophysics Committee (1926–29).

Don E. Lawrence, Jr. (AM '52), electrical engineer, West Virginia Pulp & Paper Co., Charleston, S. C., died recently. Mr. Lawrence was born January 9, 1924, in Raleigh, N.C. He graduated from North Carolina State College, Raleigh with a B.S. degree in electrical engineering, and also studied at William & Mary College, Williamsburg, Va. Mr. Lawrence was the immediate past chairman of the Charleston Subsection of the Institute and had been nominated for chairman of the South Carolina Section for 1959–60.

Glenn I. Page (AM '34, M '38, F '45), vice-president in charge of operations for the Public Service Company of Oklahoma, died recently. Mr. Page was born April 10, 1901, in Des Moines, Iowa. He graduated from Iowa State College in 1925. After graduation, he entered the training program of Iowa Power & Light Company and assisted in the construction and installation of the power station in Des Moines. He joined the Public Service Company of Oklahoma in 1927 as a results engineer at the Weleetka Power Station. Later he became the operating engineer for the Southwestern District until 1946, when he became superintendent of operations and construction for the Public Service Company. He was a member of the company's board of directors in 1954 and 1955. In April of 1958, he was named vice-president in charge of operations. Mr. Page was also a member of the Oklahoma Society of Professional Engineers and the National Society of Professional Engineers.

Paul Harris Robbins (AM '46, M '53), superintendent of engineering for the Metropolitan Edison Company, Reading, Pa., died recently at the age of 60. Mr. Robbins had served as superintendent for 34 years. He served as chairman of the electrical equipment committee of the Pennsylvania Electric Association and was affiliated with the Pennsylvania Society of Professional Engineers.

Charles Edward Roehl (AM '03, M '06, F '12), retired, of Brooklyn, N. Y., died recently at the age of 95. Mr. Roehl was born in 1864 in Chicago, Ill. He graduated from the University of Chicago and the University of Michigan class of 1888. Following a period of pioneer railroad building in British Columbia and the Pacific Northwest and in St. Joseph, Mo., where he constructed the first street railways, he went to Brooklyn, N.Y., in 1900. This move was made at the request of E. H. Harriman who at that time had purchased and was consolidating the many independent street and elevated railways into the Brooklyn Rapid Transit System, later the B.M.T. Mr. Roehl was in charge of the engineering of the system until his retirement in 1940 at the age of 75. Mr. Roehl in developing power and operating plans, pioneered many engineering ideas. He erected the Williamsburg Power Station of the B.M.T. which was the largest in the country and still in use today. He designed the safety signal blocks for the railways over the Brooklyn Bridge which were the forerunners of other safety devices. During the early part of his career, he was associated with Thomas Edison and George Westinghouse.

Merton Wilfred Sage (AM '10, Member for Life), died recently at the age of 74. Mr. Sage was born in Olean, N.Y., on June 18, 1884. He studied electrochemical engineering at Massachusetts Institute of Technology, graduating in 1907. For the next 2 years, he was associated with his father's manufacturing chemical business in Boston, Mass. He entered the U. S. Patent Office in April 1909, and served as an assistant examiner in the Metallurgical Division until his resignation. While in the Patent Office, he studied law at Georgetown Law School, from which he received his bachelor of law and master of patent law degrees in 1912. From 1912 until 1917, Mr. Sage was in the patent department of the General Electric Company at Schenectady, N.Y. He entered the offices of Pennie, Davis, Marvin & Edmonds, New York, N.Y., in December 1917, and on January 1, 1921, became a member of the firm. He was admitted to the bar of the District of Columbia in 1912, to the bar of New York State in 1913, and to the bar of the U. S. Supreme Court in 1928. He specialized in metallurgical, electrochemical, and chemical patent matters. Mr. Sage was a member of the American Bar Association, American Patent Law Association, New York Patent Law Association, American Institute of Mining, Metallurgical and Petroleum Engineers.

William Morrison Shortley (AM '42, M '51) engineer, Southern Bell Telephone & Telegraph Company, Birmingham, Ala., died recently at the age of 53. Mr. Shortley was born on October 21, 1906, in Auroa, Ill. He began working for the Southern Bell Telephone & Telegraph Company at Huntington, W. Va., in 1925. He held various assignments in engineering and plant departments of the company and was a member of the State Engineering Organization of Alabama in Birmingham, at the time of his death. Mr. Shortley was a registered professional engineer in the State of Georgia, and was a member of the Institute of Radio Engineers, and the Society of Motion Picture and Television Engineers.

Robert Edwin Turner (M '39), plant engineer, Susquehanna Electric Co., Conowingo, Md., died recently. Mr. Turner was born March 23, 1901, in Odebolt, Iowa. He received the B.S. degree in E.E. from Iowa State College in 1921. Following graduation, he entered the General Electric Company test course. From 1923 to 1926, he was employed by the Pennsylvania Water & Power Company. He became associated with the Philadelphia Electric Co. and its subsidiaries in 1926. Mr. Turner was a member of Tau Beta Pi, Eta Kappa Nu, Pennsylvania Electric Association, and American Meteorological Society.

Raymond A. Waite (M '44), retired, of Yonkers, N.Y., died recently at the age of 69. Mr. Waite was born in Santa Ana, Calif., and graduated from the University of California. After graduation, he joined Otis Elevator Company where he worked in electrical engineering research. He retired in 1955 after 40 years service with the company. Mr. Waite was a member of the New York State Society of Professional Engineers. He had served on the AIEE Metallic Rectifiers Committee.

Frederick Charles Weems (M '50), Mississippi chief engineer, Southern Bell Telephone & Telegraph Company, Jackson, Miss., died recently. Mr. Weems was born August 16, 1895, in Shubuta, Miss. He received a B.S. degree in E.E. in 1916 from Mississippi State College. After graduation, he joined Southern Bell Telephone & Telegraph Company, where he held such positions as exchange plant engineer and central office equipment engineer. He was named Mississippi chief engineer in 1949.

SPARROW III, the U.S. Navy's air-to-air missile, is now operational with the Seventh Fleet in the western Pacific. Capability against aerial attack is enhanced by squadrons armed with missile on the USS Midway *and* Bon Homme Richard.

Photos courtesy Navy's Bureau of Aeronautics and Raytheon Manufacturing Co.

Supersonic Air-to-Air Defense Feature of Sparrow III Guided Missile

CARRIER-BASED jet interceptors with the newest air defense missile, the Sparrow III, are operating with the Seventh Fleet in the western Pacific. The new missile, details of which were announced by the U.S. Navy, greatly strengthens the Fleet's defensive capability against aerial attack.

Developed and produced for the Navy by Raytheon Manufacturing Company, this new electronically controlled missile can be fired with greater aiming leeway because, in flight, it acts for itself and has the ability to track down and destroy its target.

Squadrons operating aboard the carrier *USS Midway* and *Bon Homme Richard* are now armed with the slender supersonic Sparrow III, which is said to be able to deliver a warhead with at least 50% more explosive force than any previous United States air-to-air guided missiles.

Although similar in outward appearance to an earlier Sparrow model, the new weapon is endowed with a more advanced guidance system and unique radar technique which provide many combat advantages.

Major Features

- With the Sparrow III, the pilot can get his shots off faster without sacrificing accuracy.
- The missile has a longer range than its predecessor.
- The pilot can fire at the target without even seeing it. A light on the radar scope tells him when the target is within missile range.
- The missile can be set to fire at the target automatically when within range at a pushbutton signal from the pilot.
- The pilot has greater maneuvering freedom, a major advantage in high-speed air battles. Sparrow III can be fired in many combat situations in which firing of other air-to-air missiles is not practicable.
- Targets can be destroyed in head-on attacks at very high closing speeds.
- Pilots can fire at "enemy" aircraft flying at higher altitudes than they themselves can reach, or fire from any approach angle within a relatively wide margin of aiming error, and still hit the mark. With earlier weapons, the pilot was forced to maneuver his plane into an exact firing position for a definite period of time before firing.
- The Sparrow III weapons system characteristics permit the pilot to launch his weapon before coming within range of conventional defensive armaments of enemy planes.

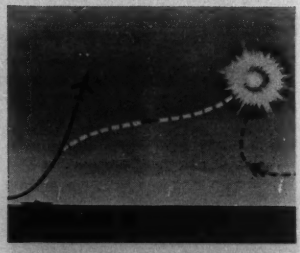
Fighter Aircraft Armament

Primary armament on the all-weather McDonnell *F3H-2* Demon, the Sparrow III is to be installed in the new *F4H-1*. In addition, other Navy fighter aircraft will carry the supersonic Sparrow III. A solid propellent rocket motor drives the missiles.

Radar installations on planes scan the skies continuously, and when the target is sighted on the scope and "locked on," the missiles are ready to fire.

►BLAST OFF of Sparrow III is shown in series of photographs in two columns. Rapid-fire sequence shows the U. S. Navy's second-generation missile being launched from *F3H-2* Demon all-weather interceptor. Plane can carry four of the missiles. Each Sparrow III can be fired singly or in rapid series. The supersonic missile delivers a warhead with at least 50% more explosive force than previous United States air-to-air guided missiles. Pilot sets missile to fire at target automatically when within range.

◄ON THE ATTACK, picture 5, the Sparrow III is shown a split second after firing. The newest air-to-air guided missile in the U.S. Navy's arsenal streaks toward "enemy" target for the kill. Squadrons of *F3H-2* interceptors on the *USS Midway* and *Bon Homme Richard* are armed with the Sparrow III, thus strengthening the Fleet's defense capability against aerial attack. The series of pictures in these two columns show the rapid-fire sequence of the launching of one of these second-generation air-to-air guided missiles.



HUNTING AND DESTROYING its target is the task of the U.S. Navy's Sparrow III. The air-to-air guided missile clings to "enemy" target despite evasive tactics. Fired from any approach angle, the Sparrow III still hits its mark, giving the pilot a major advantage in high-speed aerial battles. With earlier weapons, pilot had to maneuver into exact firing position to make the kill.

As soon as a light indicates the target is within range, all the pilot needs to do to launch the missile is to press the release button. From then on, the missile is self-actuated. The Sparrow III air-to-air missiles can be fired either one by one or in rapid sequence.

Having been released from the aircraft, the Sparrow III pursues the target despite any evasive tactics in the "enemy's" attempts to escape. The air-to-air missile tracks, computes the necessary course to fly, and follows the path to collision with the target. Its course is continually corrected during its flight from information which improves in accuracy as the missile approaches its target. The powerful warhead gives it a high probability of a "kill."

Advanced engineering design has been combined with the new packaging techniques to make the electronic part of the Sparrow III simple, small, and light. Overall length is about 12 feet, and body diameter is 8 inches. It weighs about 350 pounds.

The Sparrow III system includes a Raytheon fire-control computer and other electronic devices in the aircraft itself. Designed to provide an extra margin of reliability, fewer rejects are expected in large-scale production of the new missile.

Aboard Navy carriers, the preflight Go, No-Go check tells whether the missile will operate correctly, thus simplifying the preflight procedure.

In flight, prior to being launched, the "ready condition" of the missile is transmitted to the pilot.

Engineering of the Sparrow III system is being performed at Raytheon's laboratory at Bedford, Mass., and production of the missile and associated elements of the system for the Navy Bureau of Aeronautics is at plants at South Lowell, Mass., and Bristol, Tenn.

ON KUL, ON SPN, GO RGT, TL LFT, CIRCLE/CTR AT, +2, +3, RADIUS, +5

YOU ARE WRONG; the typographer did not make a mistake in setting the headline. This strange sentence is written in the language of the APT System, a new method for operating machine tools.

Translated, the sentence states: "Turn on the coolant, turn on the spindle, go right with the tool on the left side along the circle whose center is located at x equals 2, y equals 3, with a radius of 5."

Computers do many things for industry, science, and education. A significant improvement in the automatic control of machines that is expected to increase the productive capability of the American defense industry was recently demonstrated at the Massachusetts Institute of Technology (MIT). Called the APT System (automatically programmed tool), the new technique uses a high-speed digital computer instead of men and desk computers to calculate the numerical data that is necessary to program the motions a numerically controlled machine tool makes in cutting metal components for aircraft, missiles, or other products.

English-Like Language

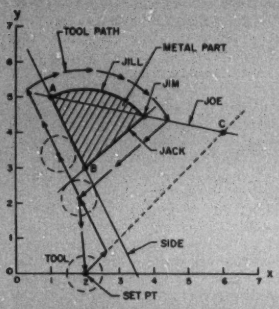
The key to the system is a relatively simple, English-like language with which the human can communicate parts descriptions and cutting sequences directly into the computer. Designed primarily for the convenience of the human programmer, this language can be translated and understood by the computer. The language thus permits people with no knowledge of computers to control complex calculations. Because of this simplicity, personnel with tooling or production experience using the APT System can make use of the full potential of high-speed digital computers. Once given to the computer on cards, the language activates the computer program so that computations for cuts are made, and proper information is coded on the machine control tape. Electrical devices on the machine tool, set into action by the punched tape, guide cutter motions properly.

Co-operative Efforts

The APT technique was developed at MIT's Servomechanisms Laboratory over a period of 2 years, marked by close cooperation on a nation-wide mutual effort with the 19-member Aircraft Industries Association (AIA) and the U. S. Air Force (USAF) Air Materiel Command (AMC) Manufacturing Methods Division Aeronautical Systems Center. This is the first time that a technical effort of this scope has been mutually undertaken by a group of such size and importance.

In addition to the financial and technological benefits realized through using automatic programming, the method reduces the all-important lead-time necessary in developing new weapons systems.

Numerically controlled machine tools have been operating on an increasing scale since 1952, following the first demonstration of the method. Today, a considerable number of plants turn out components through use of numerical control (*Electrical Engineering*, May 1958, p. 430).

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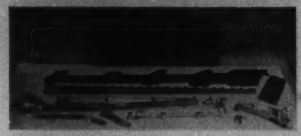
A   =  POINT/ 1, 5
B   =  POINT/ 2, 3
C   =  POINT/ 5, 4
       TL DIA/ +1.0, INCH
       FEDRAT/ 30, IPM
SET PT = FROM, POINT/ 2, 0
       IN DIR, POINT/ C
SIDE   = GO TO, LINE/ THRU, A, AND, B
       WITH, TL LFT, GO LFT, ALONG/ SIDE
JILL   = GO RGT, ALONG, CIRCLE/ WITH, CTR AT, B, THRU, A
JOE    = LINE/ THRU, A, AND, C
JIM    = POINT/ X LARGE, INT OF, JOE, WITH, JILL
JACK   = LINE/ THRU, JIM, AND, B
       GO RGT, ALONG/ JACK, UNTIL, TOOL, PAST, SIDE
       GO TO/ SET PT
       STOP, END, FINI
```

COMPLEX METAL PARTS are cut out by machine tools in the new APT System using computers which get written instructions. MIT scientists and engineers working for the U.S. Air Force developed the Automatically Programmed Tool System with co-operation of Aircraft Industries Association companies. The part program, compared with the diagram, can be read by use of "APT language" abbreviations which are: TL, tool; DIA, diameter; FEDRAT, feed-rate; IN DIR, in direction of; LFT, left; RGT, right; CTR AT, center at; INT OF, intersection of.

JET TANKER aircraft stabilizing fitting *(left)* manufactured by Rohr Aircraft Corporation, Calif. At APT System demonstration in the Servomechanisms Laboratory at MIT, the potential great savings in time and money to produce a complex part such as this were shown.

WING SPAR CAP for F-105 aircraft is being produced in quantity lots through numerical control by Republic Aviation Corporation. Previous machining time was 27 hours; APT System time is 12 hours.

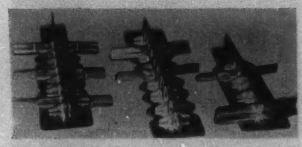
BRUSHING away metal chips is practically only manual operation needed in APT System of operating machine tools. Inset shows punched tape that feeds information to milling machine. Holes in tape are cut by means of directions from digital computer which has been furnished program for cutting part through English-like language, key to system.



SMALL PARTS manufactured on numerical control machines at Convair, Division of General Dynamics Corporation, Fort Worth, Texas. All parts were programmed with aid of large general-purpose digital computer.

Many have developed interim automatic programming methods pending development of APT, and parts are being produced by these interim methods.

The APT System has two important advantages: First, its unique language has been designed so that a standard procedure can be utilized throughout the aircraft industry and the missile industry. Second, the system is purposely designed for future growth to accommodate more-complex parts and further reduce human effort.



SPLICE VENT fittings for the *B52G* bomber are shown after completion of machining on numerically controlled profile mill at Boeing Airplane Company's Wichita (Kans.) Division.

According to its developers, the APT System has a "general skeleton program representing a systematized solution to the problems of moving a cutting tool in space." The skeleton program can be "fleshed out" for any particular application by adding to it the cutting directions for each surface involved so that a specialized computing program may be made for the particular problem.

Convenience

The common language of the APT System is natural and convenient for people to use. It can be translated automatically from human terms into computer terms

FITTING for nine door of *Seamaster* jet seaplane machined from aluminum alloy on numerically controlled milling machine recently installed at The Martin Company's Baltimore Division.

and parts can thus be produced much faster than by manual programming. In its present state of development, the APT system has not completely eliminated the need for manual programming. A year-long field trial period by AIA companies, plus research at MIT, has indicated that a significant number of parts now being manufactured can be produced with the present system. Complete elimination of any manual programming is being thoroughly investigated for future improvement of the method.

First Public Showing

The demonstration at the Servomechanisms Laboratory gave visitors a step-by-step preparation of automatic programming and a technical description of the process, as well as the history of the program from representatives of AIA, AMC, and MIT.

Initial industry-wide testing of the APT System gave AIA participating companies a field trial package of 8,000 computer cards and 200 pages of preliminary program documentation. The first programs, and those subsequent, were written for use on the IBM (International Business Machines) *704* computer because the majority of the AIA companies owned or were about to obtain the IBM *704*. It has been established that medium-sized computers, and possibly even smaller versions, can utilize the APT System.

Present schedules call for early release of APT documentation prepared by MIT. These data will consist of six separate volumes with a total of more than 600 pages of text, diagrams, and charts. All 19 AIA member companies will receive initial distribution, as well as a broad segment of national industry, research organizations, etc. Documented revisions resulting from refinement of the method will be available at a nominal charge (reproduction and mailing costs) from AIA's Los Angeles Office. All inquiries should be addressed to Technical Service, Aircraft Industries Association, 7660 Beverly Blvd., Los Angeles, Calif.

Man-Hours Saved

Typical of the technological breakthrough in programming complex part shapes is the reduction in time for manufacture of a wing rib shape which originally required 200 man-hours when programmed manually. It now takes 5 hours to make the same part using the APT computer method.

The APT System is used in the following sequence of action. The designer conceives the part. A draftsman makes detailed drawing of the part. The part program then is written in APT language, giving the directions to the machine for its work in making the part. The part program statements are punched into cards in order for the APT computer to be able to read them. These cards cannot be read by a general-purpose computer, so first a set of master cards (the work of many different agencies working through the APT program) are read in changing it into an APT computer. Then, the part program cards are fed into the APT computer from which emerges a punched tape. The punched tape is fed into the milling machine director, the "blank" piece of metal set in place, and the part automatically made.

These advantages are now ready for large-scale exploitation by machine tool builders, systems builders, and American industry in general. To this end, AIA, MIT, and the USAF stand ready and are anxious to co-operate.

Future Meetings of Other Societies

The Institute of Radio Engineers

National Symposium on Microwave Theory & Techniques, June 1-3, Harvard U, Div of Applied Physics, Paine Hall, Cambridge, Mass. R. A. Rivers, Aircom Inc, 354 Main St, Winthrop, Mass.

3rd National Conference on Production Techniques, June 4-5, Villa Hotel, San Mateo, Calif. Wm Patton, Sylvania Elec. Defense Lab, Mountain View, Calif.

Symposium on Electromagnetic Theory, joint URSI, June 15-20, U of Toronto, Toronto, Ont, Canada. Geo Sinclair, U of T.

International Symposium on Circuit & Information Theory, June 16-18, UCLA, Calif. Prof Harold Davis, UCLA, Los Angeles 24, Calif.

3rd National Convention on Military Electronics, June 29–July 1, Sheraton Park Hotel, Washington, D. C. Charles DeVore, 3224 16th St, NW, Washington 10, D. C.

11th Annual Mid-America Electronics Conference (MAECON), Nov 3-5, Municipal Auditorium & Hotel Muehlebach, Kansas City, Mo. *Deadline for papers:* July 1. Send to: Dr. S. L. Levy, Midwest R's'ch Inst, 425 Volker Blvd, Kansas City 10, Mo.

National District Heating Association, Golden Anniversary Meeting, June 1-4, Skytop Club, Skytop, Pa. J. F. Collins, Jr, 827 N Euclid Ave, Pittsburgh, Pa.

5th World Petroleum Congress Exposition, June 1-5, New York Coliseum, New York, N. Y. E. K. Stevens, 5th WPCE, 480 Lexington Ave, New York 17, N.Y.

ASHAE, Semiannual Meeting, June 7-11, Vancouver, B. C., Canada. A. V. Hutchinson, ASHAE, 62 Worth St, New York 13, N. Y.

Instrument Society of America

2nd International Symposium on Gas Chromatography, June 10-12. E Lansing, Mich. H. S. Kindler, ISA, 313 Sixth Ave, Pittsburgh 22, Pa.

2nd Nuclear Instrumentation Symposium, June 24-26, Idaho Falls, Idaho. H. S. Kindler, same.

ASME, Semiannual Meeting, June 14-18, Chase-Park Plaza, St. Louis, Mo. L. S. Dennegar, 29 W 39 St, New York, N.Y.

NSPE, Annual Meeting, June 17-20, Commodore Hotel, New York, N. Y. K. E. Trombley, NSPE, 2029 K St, NW, Washington 6, D. C.

The Society of Nuclear Medicine, 6th Annual Meeting, June 18-20, Palmer Hse, Chicago, Ill. S. N. Turiel, SNM, 750 N Mich Ave, Chicago 11, Ill.

ASTM, Annual Meeting, June 21-26, Chalfonte-Haddon Hall, Atlantic City, N. J. ASTM, 1916 Race St, Philadelphia 3, Pa.

ASRE, Annual Meeting, June 22-24, Lake Placid Club, Lake Placid, N. Y. ASRE, 234 Fifth Ave, New York, N. Y.

Air Pollution Control Association, Annual Meeting, June 22-26, Hotel Statler, Los Angeles, Calif. H. M. Pier, APCA, 4400 Fifth Ave, Pittsburgh 13, Pa.

Association for Computing Machinery, 14th Annual Meeting, Sep 1-3, MIT, Cambridge, Mass. J. H. Wegstein, ACM Program Committee, NBS, Washington 25, D. C.

Overseas

1959 International Plastics Exhibition, June 17-27, Olympia, London, England. Derek Page, Dorset House, Stamford St, London SE 1, England.

IEC, Annual Meeting, June 30–July 10, Madrid, Spain. K. G. Ellsworth, American Standards Association, 70 E 45 St, New York 17, N. Y.

British Institution of Radio Engineers, Convention on TV Engineering in Science, Industry, and Broadcasting, July 1-5, U of Cambridge, England. BIRE, 9 Bedford Sq, London WC 1, England.

Venus Two-Way Contact Makes Radar Echo-Return History

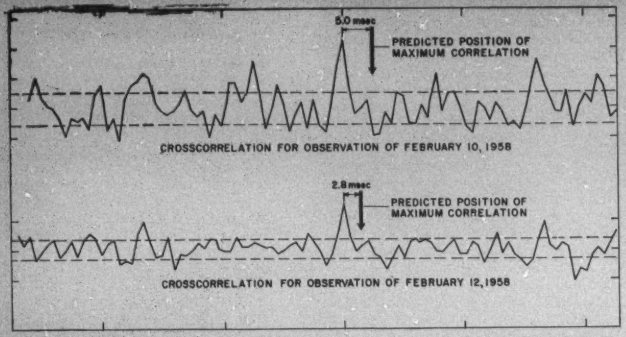
THE FIRST successful attempt to establish radar contact with the planet Venus was reported recently by a research team led by Dr. Robert Price and Dr. P. E. Green, Jr., from Lincoln Laboratory of the Massachusetts Institute of Technology (MIT). This experiment with radar astronomy achieved a one-hundredfold increase in the longest range ever attained with radar and is the first instance of a direct two-way contact with any celestial body at a distance that is far beyond the moon.

Contact Data

This contact with Venus was made at a distance of approximately 28 million miles, by the Lincoln Laboratory's powerful research radar on Millstone Hill in Westford, Mass. using a low-noise solid-state maser preamplifier and sophisticated mathematical and electronic computing techniques. The radio waves were detected after traveling a total round-trip distance of about 56 million miles. The range to Venus during this experiment was more than 100 times the distance to the moon, the most distant target previously detected by radar. The moon was first detected by radar in 1946.

Lincoln Laboratory is engaged in electronics and communications research on new problems of air defense and is supported by the U. S. Army, Navy, and Air Force (USAF) Lincoln's tri-service contract is administered by the Air Research and Development Command (ARDC) through the Air Force Cambridge Research Center in Bedford, Mass.

A report of these radar observations of Venus was published on March 20 by *Science*, the journal of the American Association for the Advancement of Science. Eight Lincoln Laboratory scientists principally concerned with various phases of this experiment are joint authors of the report.


5.0 msec
PREDICTED POSITION OF MAXIMUM CORRELATION
CROSSCORRELATION FOR OBSERVATION OF FEBRUARY 10, 1958
2.8 msec
PREDICTED POSITION OF MAXIMUM CORRELATION
CROSSCORRELATION FOR OBSERVATION OF FEBRUARY 12, 1958

CORRELATION CURVES showing radar returns from Venus. The central peaks indicate exact travel time of radar waves from Earth to Venus and back, a round-trip distance of 56 million miles. Each peak is result of elaborate calculations by a high-speed digital computer on many thousands of tiny echoes. Top curve is that recorded on February 10, 1958, 2:21 p.m. (EST). Lower curve is one recorded on February 12, 1958, 12:01 p.m. (EST). Venus had passed through its point of closest approach to Earth, just under 26 million miles away, two weeks earlier.

Computer Analysis

The experiment was conducted on February 10 and 12, 1958. Since the returning radar pulses were too faint to be directly observed or measured individually, the received signals were recorded on magnetic tape and subjected to exhaustive analysis by a high-speed digital computer. Approximately a year has been required to develop and use the intricate electronic computing methods which were necessary to isolate the returned signals from the electrical noise mixed in with the recorded data. Weeks of analysis by a large, high-speed digital computer have been required to establish with certainty the existence of the radar signals returned from Venus.

CHECKING 11-foot-high klystron power tube at Lincoln Laboratory's Millstone Hill Radar Observatory, Westford, Mass., is David Hynek.

In recent years, astronomers have been eagerly awaiting the first radar detection of any one of the planets, because of the great accuracy with which radar can measure distances. Distances in the solar system are already known to a very high degree of precision relative to one another, but absolute distances are only roughly known, and optical techniques have been pushed to the limit to get even this rough degree of accuracy. The determination of any one distance more accurately would then make it possible to calculate all other interplanetary distances more accurately. It was anticipated that, if a planet were detected at all by radar, it would be detected with very high accuracy in distance.

Accurate Distance Measured

The Lincoln Laboratory experiment has produced two highly accurate measurements of the round-trip travel time of radar signals from Earth to Venus and return, on the February 1958 observations. When properly interpreted, these measurements of time should make it possible to fix the size of the solar system to an accuracy of one-thousandth of one per cent, an accuracy approaching 100 times greater than has been possible by the most refined optical methods. Preliminary calculations from the Lincoln data indicate that the dimensions of the solar system are somewhat smaller than the previously accepted value, but this interpretation requires further study.

Discrimination of the weak radar returns from the concurrent background of celestial noise was a difficult task. The conclusion that the radar detection had, in fact, been successfully accomplished is based on the presence of echo returns in two completely processed runs. The measured change in the distance from Earth to Venus over the 2-day interval between February 10 and 12 is in excellent agreement with accepted astronomical data of high accuracy.

The distance from Earth to Venus was measured in terms of the round-trip travel time of the radar signals. On February 10 this round-trip time was 295.5065 seconds. Further study will be required to determine the exact distance from Earth to Venus based on this travel time. However, with certain assumptions, such as that radar signals travel throughout the journey at a constant speed equal to the speed of light, this travel time would place Venus approximately 27,530,000 miles from Earth. This is in good general agreement with astronomical data. On the second day, February 12, the round-trip time was 302.9842 seconds, which placed Venus approximately 28,227,000 miles distant at that time.

Computing Interplanetary Distances

When the exact absolute distances have been determined by further study, these results may lead to a considerable improvement in the accuracy of all computed interplanetary distances. Distances within the solar system are commonly measured in terms of the "astronomical unit," which is defined as the mean radius of the Earth's orbit around the sun (about 93 million miles). Preliminary calculations indicate that this unit, and hence all interplanetary distances, may be 0.0013 per cent smaller than the presently accepted value. Further investigation is required to establish the validity of this indication.

MASER is being prepared by Dr. R. H. Kingston for Venus observations at MIT Lincoln Laboratory's Millstone Hill Radar Observatory.

The measured difference between the round trip travel times of the radar signals on the two days was 7.4777 seconds, indicating that Venus had moved 696,640 miles farther away from the earth during this 2-day interval. This is in close agreement with the distance increase calculated from astronomical data of high accuracy; the measured value differed from the predicted value by only 0.0022 second, or one part in 4,000, corresponding to about 200 miles in the distance of almost 0.75 million miles.

MIT Lincoln Laboratory's Millstone Hill Radar Observatory at Westford, Mass.

The high-power, long-range Millstone Hill radar was developed by Lincoln Laboratory for the USAF to be used as a research tool, primarily for the study of problems in ballistic missile defense. It is also providing valuable information on the operation and application of the radio effects of meteors and the aurora. In addition to its normal research program, it has co-operated in the NASA (National Aeronautics and Space Administration) space probe program, and the activities of the IGY (International Geophysical Year), by tracking and receiving telemetry signals from rockets and satellites as they move into space. Dr. G. H. Pettengill and L. G. Kraft, Jr. prepared the Millstone Hill radar for the special operation necessary for this experiment. Design and construction of this radar installation was carried out under the direction of H. G. Weiss.

Maser Used

A special type of amplifier called a solid-state maser was used in this experiment, the first such use of this new device with a high power radar. By reducing unwanted electrical noise to a level which permitted detection of the desired signals, the maser played a vital role in the success of the experiment. The increased radar sensitivity realized by this first practical application of a solid-state maser was equivalent to at least a fourfold increase in the power of the huge radar transmitter. The design, development, and use of the maser employed in this experiment was the work of Dr. R. H. Kingston.

This was the first recorded use of the solid-state maser, in either radio astronomy or radar astronomy, although the device has since been used elsewhere to extend the range of radio telescopes. This is also the only reported use of a maser in the ultra-high-frequency range.

Detection Methods

Since the signals returning from Venus were expected to be so faint that they could not be detected or measured individually, in spite of the increased sensitivity realized with the maser, it was necessary to devise very sophisticated methods of detecting weak signals. In each of about 600 lengthy calculations carried out on each run, about 8,000 separate signals were carefully added together in such a way as to highlight the radar returns and suppress the noise. The first step in this detection method was to transmit radar pulses in a predetermined time-interval pattern to permit their recognition and identification upon return. Second, the returning signals were recorded on magnetic tape, using a method worked out by W. B. Smith, in order to allow unlimited time for analysis. Complex electronic computation techniques designed to take full advantage of theoretically advanced computing capabilities were then developed by Dr. Price with the help of Roland Silver, Dr. Green, and T. J. Goblick, Jr.

Of utmost significance in the success of this experiment was the closest collaboration among Lincoln scientists and engineers, skilled in such diverse specialties as high-power radars, solid-state physics, and the mathematical theory of weak signal detection. Through co-operation, these specialists translated and co-ordinated the results of their own basic research into the practical working system with which this breakthrough was accomplished.

Direct A-Power Electricity Without Using Steam Turbine

A gadget that turns the energy of splitting atoms directly into electricity inside an atomic pile was tested successfully recently at the secret atomic-bomb laboratory at Los Alamos, N. M.

The inventors said they hope the device will cut by half the price of building an atomic electricity plant by eliminating the steam turbines essential with present designs.

Optimistically, they forsee the day when their invention will bring the cost of atom-produced electricity down to the level of electric power made by burning coal or oil. They call their instrument a plasma thermocouple.

But in Washington, the mood was cool. The U. S. Atomic Energy Commission (AEC) called such predictions premature while admitting that the plasma thermocouple may have great uses in space, presumably for making auxiliary electricity for rockets and satellites.

In the tests, the scientists kept a 25-watt light bulb glowing for 12 hours with a gadget as big as a flashlight dry cell. Splitting uranium atoms supplied the heat for the experiment.

In this, the invention differs radically from the atomic battery announced by the White House a few months ago. That device used radioactive elements, ashes of the uraniam fire. It produces only a few watts. The Los Alamos group seeks millions of watts.

Dr. George Grover, who heads the development group, said in a telephone interview that the plasma thermocouple might be used to power locomotives, but it would certainly be feasible for submarines and ships. He ruled out its use in automobiles.

However, he said that "in my opinion, the first uses would be for specialized military application where efficiency is not a consideration, but there is no reason why later on this method cannot compete with other conventional means of making electricity."

In theory, the device can turn 80 per cent of the heat energy of a splitting atom fuel into electricity. However, a practical limit may be closer to 30 per cent. This is the efficiency range of a very large steam-driven electric plant using coal or oil.

Furthermore, there are no barriers to manufacturing the cells in great numbers either because of the lack of material or production techniques, Dr. Grover said. "We are going to try a multiple experiment with many cells soon," he added.

But the most attractive part of the scheme is the elimination of the steam generator. All atomic plants now in being or being built first convert the heat of the atom to steam. The steam then drives electric generators.

This means that the atomic pile is, in effect, a furnace which replaces the conventional coal or oil furnace; but it turns out to be one of the most expensive furnaces ever devised. That is what has brought the cost of electricity at the Shippingport, Pa., atomic power plant to 6 cents a kilowatt-hour. Electricity generated by conventional methods costs 0.08 cents a kilowatt-hour.

How does the thermocouple work? It is based on a very old principle, namely, that if you weld two different metals together and heat the joint you produce a flow of electrons—electricity.

In the plasma thermocouple, a bit of pure uranium-235, the atomic-bomb fuel, is suspended in a cup the size of a fruit-juice can. The space around it is filled with cesium, another metal, but in gaseous form.

When the uranium atoms split, heating the button of uranium, electrons flow from the uranium through the gas. Such a cell operates at 3.8 volts but with a maximum current of 40 amperes.

In the tests, the device was lowered into an atomic pile at Los Alamos.. The neutrons generated by the rest of the pile caused the uranium button to be in a chain reaction. That made the heat that was needed for the uranium-cesium thermocouple.

The high efficiency comes from being able to heat the uranium button to 3,-000 F, a temperature far above current atomic-pile fuel elements. Because the uranium is isolated by the cesium gas, corrosion is also reduced, Dr. Grover added. Furthermore, there is reason to believe the uranium could be left in the pile for a long time, another contribution to efficiency, he said.

Atoms for Living Stressed in Industry-Owned Research Reactor

ALUMINUM DOME, 87 feet high, houses largest entirely industry-owned research reactor. Constructed by 10 companies in noncompeting fields to conduct basic research, the Plainsboro, N. J., installation is called Industrial Reactor Laboratories, Inc., and is jointly owned.

MAGNETITE CONCRETE, 3 feet thick was used in construction of IRL reactor. Joint owners are: American Machine & Foundry Co.; American Tobacco Co.; Atlas Powder Co.; Continental Can Co.; Corning Glass Works; National Distillers and Chemical Corp.; National Lead Co.; Radio Corp. of America; Socony Mobil Oil Co., Inc.; and United States Rubber Co.

CONCRETE POOL rises 30 feet above ground level within "beehive" dome. Shown is pool of IRL reactor where uranium-fuel core is located 27 feet below surface of the water. Platform around top of pool accommodates reactor control room and provides working space for various operations.

FUEL ELEMENTS are loaded into core of new 5 million watt nuclear reactor by technicians preparatory to the start of operations. The core of the reactor is 27 feet below the surface of the water which acts as a cooler as well as a shield for the IRL installation.

RADIOACTIVE materials at IRL are handled in shielded "hot cells." Special manipulators perform experiments remotely while operator is shielded by 3-foot thick laminated window. From outside these cells, scientists can observe and handle radioactive specimens without danger of exposure to radiation.

Program for Dissemination of Science Information Approved

President Eisenhower approved on December 7, 1958, a plan designed to help meet the critical needs of the Nation's scientists and engineers for better access to the rapidly mounting volume of scientific publication.

Acting upon the recommendations of his Science Advisory Committee, the President directed the National Science Foundation to take the leadership in bringing about effective co-ordination of the various scientific information activities within the Federal Government. The President asked that all Federal agencies whose programs involve scientific information co-operate with and assist the National Science Foundation in improving the Government's own efforts in this area.

This action by the President strengthens and reinforces the provision of the National Defense Education Act of 1958 calling for the establishment of a Science Information Service in the National Science Foundation to: "Provide, or arrange for the provision of, indexing, abstracting, translation, and other services leading to a more effective dissemination of scientific information, and undertake programs to develop new or improved methods, including mechanized systems for making scientific information available."

The President's Committee urged that fullest use be made of existing information services, both public and private, and that the Foundation's Science Information Service supplement rather than supplant present efforts.

Dr. James R. Killian, Jr., special assistant to the President for Science and Technology and chairman of the Science Advisory Committee, commented on the increasing dimensions of world scientific publication which he said had grown to the extent that it has become a problem requiring action at the national level.

"Science and engineering are largely built on the published record of earlier work done throughout the world," Dr. Killian stated. "There are, for example, 55,000 journals appearing annually, containing about 1,200,000 articles of significance for some branch of research and engineering in the physical and life sciences. More than 60,000 different books are published annually in these fields, while approximately 100,000 research reports remain outside the normal channels of publication and cataloging. Within this vast body of worldwide scientific information, published and unpublished, lie the technical data that scientists need in order to do their work. The situation is further complicated by the fact that a large and important proportion of the world's scientific literature appears in languages unknown to the majority of American scientists, such as Russian and Japanese."

In its recommendations, the President's Science Advisory Committee outlined a program calling for the review, co-ordination, and stimulation, on a nation-wide basis, of activities in the areas of primary and secondary publications, scientific data centers, unpublished research information, storage and retrieval, and translation by mechanical means.

In the opinion of the Committee no new agency will be required to carry out the recommended program. Under its enabling act, the National Science Foundation has devoted special attention to the scientific information needs of scientists and has developed a series of programs designed to help meet those needs. At least 10 other Federal agencies are engaged in abstracting and indexing, translating, preparing technical reports, and research related to information needs. These agencies have been asked to co-operate in providing or arranging for acquisition and reference programs, clearinghouse functions, and evaluation studies of existing programs. Research on new and improved methods of information-handling will be emphasized. The Department of State will take the lead in encouraging co-operation among U. S., foreign, and international scientific information organizations.

The President's Science Advisory Committee considered the whole problem of such importance that earlier in the year it appointed a special subcommittee to consider the subject at length. Headed by Dr. W. O. Baker, vice-president (research), Bell Telephone Laboratories, the subcommittee comprises the following members: Curtis Benjamin, president, McGraw-Hill Book Co.; Dr. C. P. Haskins, president, Carnegie Institution of Washington; Dr. Elmer Hutchisson, director, American Institute of Physics; Dr. W. C. Johnson, dean, Division of Physical Sciences, University of Chicago; Mr. Don K. Price, dean of the School of Public Administration and Littauer Professor, Harvard University; Dr. H. Scoville; and Dr. Alan T. Waterman, director, National Science Foundation.

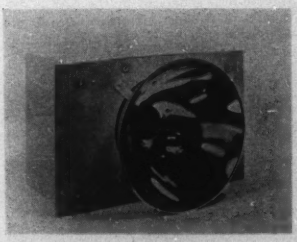
In submitting its findings, the subcommittee paid special tribute to the work of individual scientists and engineers in selecting, interpreting, and abstracting scientific and technical information. It noted the fact that the services rendered by many of the scientific societies and professional institutions to the scientific community in the information field are world famous for their quality. It expressed the hope that such private groups would continue to co-operate with and assist the Federal Government in the achievement of long-range solutions to scientific information problems.

The subcommittee's conclusions form the basis for the recommendations submitted to the President by the Science Advisory Committee.

Intense Light for Aerial Flash Unit Developed

An aerial flash unit, whose peak light output is so intense that only three would be needed to light up Yankee Stadium, has been developed by a scientific instrument firm. The light source of the unit, developed for night aerial photography, is a xenon-charged flash tube 3.5 cm high (about 1⅜ inches) and the diameter of a pencil. The flash tube is made of high-purity quartz and is shaped like the looped end of a safety pin.

At a flash duration of 1/1000 second the



PROTOTYPE aerial flash unit, XLS-1, shown above, developed by Edgerton, Germeshausen & Grier, Inc., measures 14¾ inches long, 9¼ inches wide, and 10 inches high, and weighs 32.5 pounds.

TEST SHOTS taken 288 feet from sidewalk in Boston, Mass., demonstrate range and intensity of light output of XLS-1 flash unit. A 1-second time exposure of f/18 *(top left)* shows New England Mutual Life Co. Building, and same building *(top right)* in relief from a 1/1000-second flash. Estimated range is 500 to 700 feet. Far end of Park Square building is shown *(bottom left)* in darkness as flash unit is aimed to cover portion nearest camera. Flash unit spreads light the full length of building *(bottom right)* illuminating block at an estimated range of 600 to 800 feet.

unit, developed by Edgerton, Germeshausen & Grier, Inc., Boston, Mass., delivers 90,000 beam candle power seconds at a 25° beam angle, which is equivalent to 90 million lumens. Yankee Stadium uses about 1,200 lamps of 1,500 watts each to deliver a total light output of 250 million lumens with reflectors in order to illuminate a night baseball game

Called the *XLS-1* flash unit, it has been designed for mounting in reconnaissance aircraft. The unit consists of a flash tube, polished aluminum reflector, and an 850-volt power pack. The self-contained unit weighs 32.5 pounds and is one-third the weight of present aerial flash equipment.

The flash unit produces a maximum 635 watt seconds of energy per flash. Its repetition rate is two flashes per second. Intense heat generated by the flash is dissipated by a 2-inch diameter fan capable of moving 60 cubic feet of air per minute.

More A-Power for United Kingdom

A second atomic station is pumping electricity into the British national power network. The new plant at Chapel Cross, Scotland, is a twin of the Calder Hall station which has been operating since October 1956.

One of the four Chapel Cross reactors began supplying electricity on February 25, 1959, the Atomic Energy Authority said. The other three reactors are to be switched on at 3-month intervals.

Flight Safety Helped by Easy-to-Read Altimeter

A radically different type of aircraft altimeter—said to cut reading time in half and virtually to eliminate reading error—was demonstrated recently by the Bulova Watch Company, Inc.

General Omar N. Bradley, Bulova board chairman, announced that the U.S. Air Force (USAF) is ordering a test quantity of 25 of the altimeters for extensive laboratory testing and flight evaluation in many types of USAF planes.

In addition to its readability, he said, the altimeter "is extremely accurate and highly sensitive, reacting instantaneously to changes in altitude even in very rapid ascent or descent and thus providing improvement in the safety factor of aircraft operation."

Furthermore, it was stated that the altimeter indicates altitude with an error of less than 10 feet at sea level. Gen. Bradley cited tests made by a major aircraft company, showing a deviation (plus or minus) of 20 feet for a Bulova altimeter at 12,000 feet, against a 200-foot deviation for a conventional altimeter on the same evaluation. Its sensitivity, he said, is such that raising or lowering the instrument as little as 2 feet gives a visible indication on the scale when one is at or near sea level.

Of 241 readings, 8 resulted in an error with the Bulova altimeter (3.3%); of 235 conventional type altimeter readings, 129 resulted in an error (54.9%). Average reading time for tests with the Bulova unit was 3.4 seconds. With the older type, reading time averaged 7.3 seconds. These were tests in the Laboratories.

Flight tests were also made and results tabulated from installations in a Boeing *707* commercial jet transport, *KC-135* USAF jet transport-tanker, *YC-97J* USAF turbo-prop transport; Convair *C-131* USAF transport, Douglas *DC-8* commercial jet transport, *C-133* USAF turbo-prop transport, Lockheed *Electra* turbo-prop commercial transport, *F-104* USAF jet interceptor, North American *F100-F* USAF jet fighter-bomber, and a Beech Model *18* executive transport.

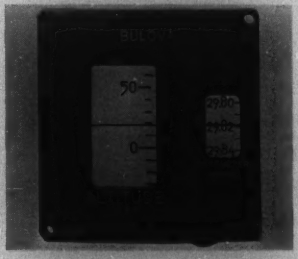
E. M. Patterson, president of the Bulova Research and Development Laboratories, Inc., explained that altitude readings are shown on a continuous logarithmic tape. The tape, about 40 feet long, ranges from minus 1,000 feet to plus 65,000 feet, and is driven past a window in the instrument by a servo motor. "It follows the true altitude without fluctuation or 'hunting'," Mr. Patterson stated.

Up until the present time, there were at least three problems associated with altimeters, as follows: (1) lag in presentation which resulted in the pilot being deprived of precise altitude information during some critical portions of flight, (2) inherent deficiency in standard USAF 3-pointer altimeter which permits inadvertent presetting, and (3) complexity of presentation which is conducive to misinterpretation.

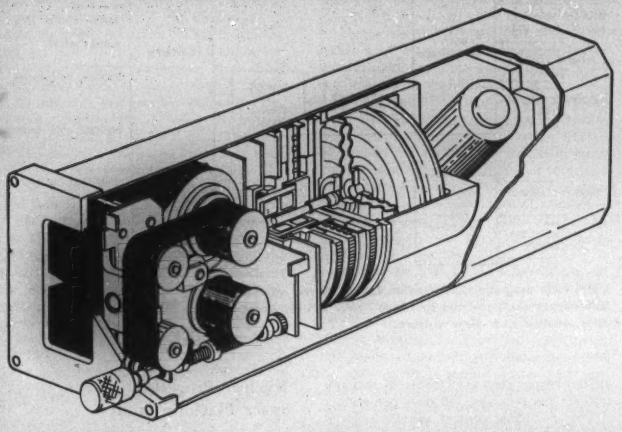
Test results to date have indicated that the new altimeter made by Bulova seems to be the most significant development in altimetry since World War I.

At sea level, the numbered graduations are separated a full inch for each 50 feet of altitude. At 20,000 feet, the numbered graduations mark each 100 feet of altitude. At 40,000 feet, the graduations stand for 200-foot increments. From 60,000 feet up, the increments are 500 feet for each inch. Smaller unnumbered graduations divide each of the major segments throughout the tape. This tape presentation supplies greatest readability and accuracy where most needed—at lower elevations and landing altitudes.

It was also stated that the altimeter's sensing elements are Melchior type aneroid capsules, and that Bulova manufactures



PILOT'S VIEW of new direct-reading altimeter, made by the Bulova Research and Development Laboratories, shows how altitude is clearly indicated on tape. Knob is used to set barometric pressure.



ALTIMETER CUTAWAY shows four basic building-block instruments, which include *(left to right)* altimeter windows, barometric correction knob, and tape drive; servo motor and acceleration compensating mechanism; three aneroid pressure capsules; and the pitot tube connection. Acceleration effects are eliminated by reverse phase signal to transistorized amplifier from additional set of coils and rod armature. Pressure capsules are also Bulova made.

these itself "to achieve consistently reliable performance."

The output of the sensing elements is transferred to the indicating mechanism electrically, freeing the sensing element of all mechanical work, eliminating friction, and producing a sensitivity previously unknown, Mr. Patterson said. It also "obviates the need for vibrational stimulation of the instrument," he added.

The new instrument is the product of a company-sponsored 4-year altimetry project conducted at the Bulova Research and Development Laboratories in Woodside, N. Y. Mr. Patterson stated that production will be carried on by the Industrial and Defense Division of the Bulova Watch Company which is located in Jackson Heights, N. Y.

Maximum Per Diem Set for Federal Consultants

A maximum per diem rate of $100 for temporary consultants engaged by the Federal Government has been urged by the National Society of Professional Engineers (NSPE) in recommendations made to Congressional Appropriations Committee chairmen.

The NSPE points out that consulting engineers have stated that current maximum per diem rates of $50 or even $75, allowed by several Federal agencies, are insufficient for the economically feasible performance of consulting engineering services because of existing high overhead expenses.

The NSPE recommendations call attention to the fact that "the net result of a Federal limitation less than $100 per day could very well be that the most qualified engineering firms would refrain from undertaking engineering projects for the Government, leaving the Government's choice to less qualified consultants, although the Federal Government deserves and is entitled to the very best engineering talent available."

The NSPE cited recent statutes creating the National Aeronautics and Space Administration and the Federal Aviation Agency as recognizing the need for adequate per diem compensation in that they contain provisions for permitting a maximum per diem allowance of $100.

The Congressional appropriations chairmen were informed that the 48,000-member engineering group "heartily endorses the principle of utilization of engineering consultants by the Federal Government on a per diem basis, or such other basis as may be mutually agreed upon. Legislation establishing maximum per diem fees should reflect an allowable per diem rate of at least $100."

The NSPE also pointed out that many state societies of professional engineers have established recommended fee schedules, each of which calls for at least a $100 per diem rate.

Ultramicroscopic Semiconductor Solid Circuit

A major developmental advance in semiconductor solid circuitry was announced recently by Texas Instruments Incorporated (TI).

By taking advantage of TI developments in such semiconductor manufacturing techniques as controlled masking, etching, and diffusion, the company has formed diode and transistor elements, as well as the passive elements of resistance and capacitance, as integral parts of single pieces of semiconductor material, both silicon and germanium. The resultant semiconductor solid circuits, each about the size of the head of a paper match, are considered to approach the ultimate in miniaturizing complex electronic circuitry, and components.

The multivibrator circuit (less than 1/4 by 1/8 by 1/32 of an inch) contains as integral parts of the semiconductor material the equivalent of 12 electronic components—two diffused-base transistors, two capacitors, and eight resistors.

With these development models, components can range in density up to 34 million per cubic foot by applying the same measurement scale for determining component densities as that used for circuits developed by conventional techniques with printed circuits.

These miniaturized circuits, called micromodules, are believed capable of yielding densities of the order of 500,000 components per cubic foot.

In addition to great reductions in circuit size and weight as compared with the smallest of circuits developed with conventional techniques, the new techniques substantially enhance the circuits' reliability because:

1. The circuits, the component equivalents, and their connections all are integrated into the semiconductor material, thus permitting predictable process controls.

2. Each circuit will be designed for a specific type of application, thus each can be checked and tested functionally during the manufacturing process.

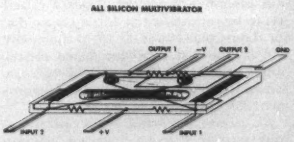


DIAGRAM of TI silicon solid-circuit multivibrator, greatly enlarged from its actual measurement of less than 1/4 by 1/8 by 1/32 inch, shows 12 equivalent components contained in the solid circuit—2 diffused-base transistors, 2 capacitors, and 8 resistors.

SILICON solid-circuit multivibrator is shown actual size, compared with head of ordinary paper match. This TI unit contains the equivalent of 12 electronic components.

3. The electronic characteristics of each component equivalent will be tailored specifically for the particular application for which it is being created.

4. Up to 75% fewer leads or connections are required as compared with a conventional circuit.

Moreover, a relatively few basic circuit models would meet the requirements in broad areas of applications because an almost infinite variety of electronic characteristics could be achieved for each individual equivalent component, providing wide selection of equivalent components for grouping within each circuit.

The new solid circuits are expected to find greatest potential application where large numbers of repetitive circuits are required, such as in the rapidly growing computer field and for rockets, missiles, satellites and all space vehicle instrumentation where weight, size and extreme reliability are the critical factors.

Among other potential fields of application are circuitry in telephones, television, radio, radar, sonar, hearing aids, dictating machines, cable carrier amplifiers, automation where the electronic portions are contained within the machines, and in medical instruments used within the human body.

Computer-Controlled Electric Power Plant

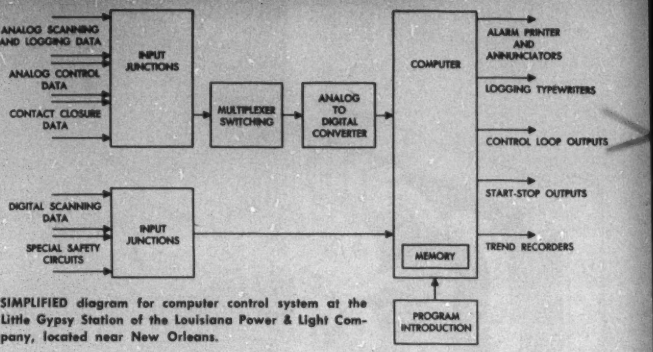
A computer-controlled 225,000-kw facility, to be constructed at Little Gypsy, La., for Louisiana Power & Light Company, will be the first fully automated electric power generating station. It will be capable of supplying the electrical requirements of a city of over 200,000.

All phases of Little Gypsy's operation—from start-up through operation to shutdown—will be controlled automatically by a special electronic computer system designed and built by Daystrom Systems, La Jolla, Calif., a Division of Daystrom, Incorporated.

A total of 800 different "steps" are involved in start-up or shut-down, according to representatives of Louisiana Power & Light Company. Between each step, they said, the computer will scan—at lightning speed—700 different temperatures, pressures, flow rates, and valve and switch positions. If all is in order, the electrical command goes out to the hundreds of valves and switches to change to the next position.

The information presented to the computer for evaluation is in the form of electric energy—at signal levels less than one tenth the strength of human brain waves!

The computer system is of the solid-state type, according to C. E. Jones, general manager of Daystrom Systems. Semiconductors are used rather than vacuum tubes—a total of 4,000 transistors and more than 7,000 diodes. For maximum operating life, there are no moving parts anywhere in the entire computer control system, according to Mr. Jones. Daystrom has guaranteed 99 per cent availability of this system—24 hours a day, 365 days per year.



SIMPLIFIED diagram for computer control system at the Little Gypsy Station of the Louisiana Power & Light Company, located near New Orleans.

The electronic control system includes the necessary equipment to perform the following functions:

1. Automatic start-up and shut-down.
2. Automatic plant control.
3. Automatic logging.
4. Automatic alarm scanning.
5. Complete system flexibility.

Little Gypsy will be staffed by the normal complement of human operators for safety and maintenance. "The real advantage of this control system results from its faster reaction and greater sensitivity," Mr. Jones declared. "Because of this," he continued, "the station can be operated much closer to actual equipment operating limits for highest over-all efficiency and, most importantly, with unprecedented safety."

In addition to continuous monitoring of all phases of the station's operation, the computer will examine itself every 2 minutes, Mr. Jones explained. If the computer finds itself "confused," it will "resign," and turn over the operation of the plant to the human operators.

Little Gypsy Station is now under construction, with Ebasco Services, Inc., as the consulting and construction engineers. It is scheduled for completion by 1961, and is expected to be one of the most modern power plants constructed.

Nuclear Propelled Space Platform Study

The concept of a 1,000-ton space platform propelled by controlled nuclear explosions which was discussed recently by R. W. Johnson, director of Advanced Research Projects Agency (ARPA) before the Senate Space Committee referred to "Project Orion" which has been under way for the past 9 months at the General Atomic Division of the General Dynamics Corporation.

This is the first time the Department of Defense has permitted identification of Project Orion. Project Orion is a feasibility study, conceived by the scientists at General Atomic and initiated in July 1958 under contract with the Advanced Research and Development Command of the U. S. Air Force with authorization of the ARPA. The research is being conducted at General Atomic's John Jay Hopkins Laboratory for Pure and Applied Science at San Diego, Calif.

The initial commitment for this study calls for the expenditure of $1 million during the fiscal year 1959. Continuation of the project will be based upon the results of the study during the initial phase. Mr. Johnson emphasized the study nature of this contract, if successful, may lead to a very distinct advance in propulsion capability.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, *Electrical Engineering* reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Questionnaire Results

February 3, 1959

To the Editor:

At the top of page 17 of the February issue of *Electrical Engineering*, you have printed a numerical summary of the results of the NSPE questionnaire. A summary should give an accurate concise view of a situation as it actually exists, but that was not true in this case.

One would conclude from the table that AIEE registered engineers were about equally divided between those who are members of NSPE (46%) and those who

were not (54%). Actually, 6,955 registered engineers answered the questionnaire; of these, 2,240 are members of NSPE and the rest are not. Of the registered engineers' answers to the questionnaire, over 2,300 were thrown out of the summary, apparently on the technicality that they answered question No. 5, when they were not required to do so. Of these 2,306, there were 1,681 who indicated that they were not interested in belonging to NSPE.

The writer submits that all the information may be found in the elaborate table at the bottom of the same page. However, the Directors must have recognized that most of our members would not devote the time to digest all of its 100 odd items or the summary would not have been considered necessary. It is all the more important, therefore, that the summary should have been entirely unbiased.

WARD HARRISON (F '36)

(Consulting Engineer, Lighting, Cleveland 22, Ohio)

February 19, 1959

Dear Mr. Harrison:

Your letter of February 3 raising some interesting questions about the analysis of the results of the recent questionnaire as published on page 177 of *Electrical Engineering*, February 1959, was referred to the responsible committee. The Inter-Society Relations Committee has asked me to respond as follows:

"It is correct that 6,955 respondents answered in the affirmative, the question 'Are you a Registered Professional Engineer?' and that of these 6,955, just 2,240, or 32%, indicated that they are members of NSPE. Of the 9,934 replies received and tabulated on the lower half of the page, the analysis at the top of the page ignores 2,536, including the 2,306 you refer to.

"You make the point that of the 2,306, there were 1,681 who indicated that they were not interested in joining NSPE. At first glance, it would appear that this could be said of 2,196 out of the 2,306 who are eligible to join NSPE and have not done so. But then, what about the 567 who say that they are registered and eligible to join NSPE, have not done so, but would if nonregistered Members and Fellows of AIEE were eligible. This indicates some lack of understanding or failure to read the instructions carefully.

"There is always danger in accepting some part of a reply to a questionnaire when there is an inconsistency or failure to follow instructions. To do so involves using judgment as to which part to accept and which to reject. Failure to read and follow the instructions carefully raises a question as to the care with which any particular part was answered and therefore as to its accuracy.

"It may be a fact that 6,955 of the respondents are registered and that only 2,240 (32%) of these are members of NSPE but, for the reasons discussed above, the analyst declined to draw this conclusion and preferred, as indicated above the table, to use only those replies which were consistent with the questionnaire in all respects. The entire picture was presented in the table at the bottom of the page.

"At any rate, as the introductory statement related, the purpose of the questionnaire was to assist in further discussions with NSPE of the AIEE suggestion that membership be opened to nonregistered Members and Fellows, and here there is evidence of widespread interest in joining NSPE."

Cordially yours,

C. S. RICH
Editor

Magnetospherics and Electrospherics

To the Editor:

The article on this subject by A. D. Moore in the February issue recalls two experiences with this interesting field. One involved small glass beads made by Potter Bros. of Carlstadt, N. J. When a glass or plastic vial half full of these tiny glass spheres is electrostatically charged, some rather odd effects are produced. This suggested not only electrostatic-field plotting, but also a scientific children's toy. Other companies such as Linde & Ace, make sapphire and nylon spheres.

The other was a crude ball-rotor synchronous hysteresis motor devised by the writer when still in high-school, more years ago than he cares to recall. It consisted of two simple iron-core solenoids spaced end-to-end. One coil was fed direct current and a steel ball bearing allowed to cling to the pole rim. When the other solenoid was fed alternating current, the ball "took off" in a synchronous-rpm spin around the circular pole rim.

Using an r-f power oscillator or a high-frequency Alexanderson generator, such a ball rotor might be brought up to very high rpm's in a chute type raceway to permit gyro-force studies of high-speed jet-engine bearings. It could also be used to produce high-velocity test projectiles, possibly.

TED POWELL

Directional Antenna Systems

To the Editor:

Dr. G. H. Brown's paper, "Improving Stability of AM Directional Antenna Systems," on p. 214 of the March 1959 issue of *Electrical Engineering*, discusses an inversion method of obtaining more favorable operating impedances for AM directional antennas. Practicing engineers have found the method described by Dr. Brown of considerable value in avoiding operating impedances which might result in unstable operation.

The method proposed by Dr. Brown can be extended by fairly simple processes to provide improved results in a large number of cases where simple geometrical inversion, as discussed in the article, will not work. For example, in Fig. 5 of Dr. Brown's article, an array is shown in which no change in the operating impedances results from the application of the inversion method.

Another array in which simple inversion will not bring about any changes is shown in Fig. 1, in which I have retained the notation employed by Dr. Brown. Fig. 1 (A) shows the original set of operating parameters, and Fig. 1 (B) the set obtained by applying a simple inversion.

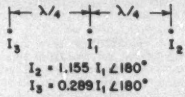


Fig. 1 (A)

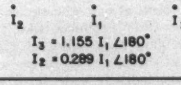


Fig. 1 (B)

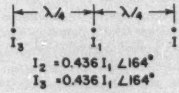


Fig. 2 (A)

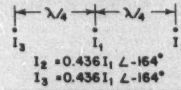


Fig. 2 (B)

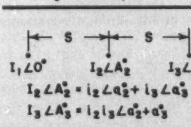


Fig. 3

The same radiation pattern can be obtained, however, by either of the sets of parameters shown in Fig. 2 (A) or 2 (B), although the method of arriving at the new parameters probably would not be clear without something more in the way of explanation.

In designing in-line directional antennas which employ equal spacing between adjacent elements, it is common practice to consider the currents in the towers as being composed of two or more individual

vector currents. For example, in the 3-tower array shown in Fig. 3, the actual operating currents shown may be equally well represented by the indicated resolution into individual vectors. This approach has the advantage of permitting the pattern of the array to be calculated by means of the following equation:

$$\overline{F} = K\left[\left(I_1\angle 0° + i_2\angle a_2° + \frac{360° S}{\lambda}\cos\phi\right)\left(I_1\angle 0° + i_3\angle a_3° + \frac{360° S}{\lambda}\cos\phi\right)\right]^{\frac{1}{2}} \quad (1)$$

which provides considerably more rapid calculation than the use of the general equation

$$\overline{F} = K\left[I_1\angle 0° + I_2\angle A_2° + \frac{360° S}{\lambda}\cos\phi + I_3\angle A_3° + \frac{720° S}{\lambda}\cos\phi\right] \quad (2)$$

The equation has the further advantage of facilitating the establishment of the angular position of the individual minima of the pattern, which will occur at the angles where either of the expressions

$$\left[I_1\angle 0° + i_2\angle a_2° + \frac{360° S}{\lambda}\cos\phi\right] \text{ or}$$

$$\left[I_1\angle 0° + i_3\angle a_3° + \frac{360° S}{\lambda}\cos\phi\right]$$

is a minimum.

It will be noted that these latter expressions are identical with the equations for simple two-tower antennas, and it is fairly easy to show that either of these component two-element expressions can be treated independently with the inversion method as shown in Dr. Brown's Fig. 1. These component inversions will, in general, change the operating impedances of the array without producing any changes in the radiation pattern.

For example, the array shown for illustration in Fig. 1 was based on individual vector currents of

$$i_2 = 0.5\ I_1\angle 150°$$
$$i_3 = 0.5\ I_1\angle -150°$$

The inversion of Fig. 2(A) was obtained by substituting $i_3 = 2I_1\angle -150°$ for $i_3 = 0.5\ I_1\angle -150°$ and that of Fig. 2(B) by substituting $i_2 = 2I_1\angle 150°$ for $i_2 = 0.5\ I_1\angle 150°$. In general, there are four different sets of base operating parameters associated with any equally spaced three-tower in-line antenna, although if $I_1 = i_2$ or $I_1 = i_3$, or if $a_2 = a_3$, two of these become identical. In the case of the array shown on Dr. Brown's Fig. 5, $I_1 = i_2 = i_3$, and $a_2 = a_3 = 90°$, which results in the unique set of parameters shown.

The same technique is frequently extended to arrays of four or more towers, and may be employed with as many towers as desired as long as the two required conditions are met; namely, that the towers be oriented in line and that the spacing between all adjacent towers be equal. For an array of this sort consisting of n towers, an equation of the form shown in equation 1 will contain $(n-1)$ component terms. It will be seen that by applying inversion to each of these terms independently a total of $2^{(n-1)}$ sets of base operating parameters can be provided.

In those instances where none of the $2^{(n-1)}$ sets provides the requisite stability, the further methods described by Dr. Brown in his article can be applied to improve the functioning of the array.

Yours very truly,

HOWARD T. HEAD

(A. D. Ring & Associates, Consulting Radio Engineers)

CORRECTION—In the March 1959 *Electrical Engineering*, "New Books" section, p. 289, the number of pages, size, and price of the "Bibliography and Abstracts on Electrical Contacts," 1957 Supplement, were incorrectly quoted because of pied type. The edition, published by the American Society for Testing Materials, contains 49 pages, is 6 by 9 inches, and costs $1.75.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

THE ALGEBRA OF ELECTRONICS. By C. H. Page. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J., 1958. 258 pages, 6 by 9 inches, bound. $8.75. The book reviews the mathematical principles involved in the solution of problems in the field of circuit theory and design. Starting with graphs of networks and the relation of Kirchhoff's law to Ohm's law, the author continues with loop-branch relations in tabular form, model analysis, determinants, Laplace's expansion of determinants by cofactors, solution of simultaneous equations, and Fourier waveform analysis. Applications to specific problems are considered and include series tuned circuits, impedance matching, amplifiers, noise, modulation, demodulation, and distortion.

ANALYSES OF INDUSTRIAL OPERATIONS. Edited by E. H. Bowman and R. B. Fetter. Richard D. Irwin, Inc., Homewood, Ill., 1959. 485 pages, 6¼ by 9¼ inches, bound. $9.55. Case studies that show the actual application of quantitative methods to the analysis of industrial operating problems are presented. The studies included are arranged according to method of analysis, and sections are given dealing with applications of linear programming, other programming applications, waiting line applications, total cost and value models, and applications of incremental analysis. The studies selected are intended to illustrate the simplifications, assumptions, method modifications, data needed, action, and results associated with operations analyses.

ANWENDUNG VON RECHENMASCHINEN BEI DER BERECHNUNG VON REGELVORGÄNGEN. Edited by W. Oppelt. R. Oldenbourg, Munich, West Germany, 1958. 128 pages, 6¼ by 9½ inches, bound. 13.50 DM. This symposium, held in 1957 by the Fachausschuss Regelungsmathematik of the Gesellschaft für angewandte Mathematik und Mechanik, contains 10 papers on the use of computers in setting up control engineering processes, of which one, "A Simple, Graphical Method for Deconvolution," by J. B. Reswick, is in English. Although most of the papers deal with applications of analog computers, there is one comparison of the use of various computer types in control engineering.

CAREERS AND OPPORTUNITIES IN ENGINEERING. By Philip Pollack. E. P. Dutton and Company, Inc., 300 Fourth Ave., New York 10, N. Y., 1959. 140 pages, 5½ by 8 inches, bound. $3.50. The author indicates what personal traits and abilities are needed for success in various fields of engineering and discusses educational requirements and engineering courses. The actual work performed by engineers in different areas is described as are salaries and prospects for advancement. Also included is a brief history of engineering and a chapter on opportunities for women.

COST REDUCTIONS IN WIRE COMMUNICATIONS. By Roy Stone. Revised edition. The Christopher Publishing House, 1140 Columbus Ave., Boston 20, Mass., 1959. 350 pages, 6¼ by 9½ inches, bound. $10. A detailed analysis of business operating costs relating to telecommunications and how they may be reduced through the selection and use of proper facilities is presented. The author discusses telephone service for the small, medium, and large business; toll and long-distance expense; the telephone room and operator training; privately owned systems; teletypewriter exchange service and teletype leased lines; commerical telegrams; teletype switching systems; and administration and management.

ELECTRICAL ENGINEERING MATERIALS. By A. J. Dekker. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1959. 208 pages, 6 by 9¼ inches, bound. $8. The basic physical processes responsible for properties of materials are stressed in this volume, which contains sections on dielectric properties of insulators in static fields, behavior of dielectrics in alternating fields, magnetic properties of materials, conductivity of metals, mechanism of conduction in semiconductors, and junction rectifiers and transistors. Simple classical or semi-classical models are used to develop insight into the physical mechanisms described.

ELECTRONIC WAVEGUIDES. Edited by Jerome Fox. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 1958. 418 pages, 6¼ by 9 inches, bound. $5. The book includes papers dealing with such aspects as traveling wave tubes, dynamics of electron beams and plasmas, electron-beam waves in microwave tubes, electron-plasma oscillations, propagation in ion-loaded wave guides, double-stream electron-beam systems, boundary conditions at the surface of a slow-wave circuit, nonlinear O-type backward wave oscillators, space and time harmonics in electron beams, and high magnetic field submillimeter wave generators with parametric excitation. This volume comprises the proceedings of a symposium in New York in 1958 and is issued as volume 8 in The Microwave Research Institute Symposia Series of the Polytechnic Institute of Brooklyn.

ENGINEERING MANUAL. Editors-in-chief J. H. Perry and R. H. Perry. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. Various pagings, 5¼ by 7¾ inches, bound. $9.50. This manual brings together in one volume data and methods used in the architectural, chemical, civil, electrical, mechanical, and nuclear engineering fields. Mathematics, mathematical tables, and physical and chemical data common to all the engineering sciences are presented in sections prefacing the manual. Additional tables, graphs, and formulas are included in the appropriate sections.

FERNSCHREIB - VERMITTLUNGSTECHNIK. By Ehrhard Rossberg and Helmut Korta. R. Oldenbourg, Munich, West Germany, 1959. 343 pages, 6½ by 9½ inches, bound. 35 DM. A comprehensive treatment of teletype switching equipment, the book provides not only full descriptive information but also deals with planning, maintenance, and the measurement of traffic data. The book gives

a survey of the various major systems, both with and without direct connection from subscriber to subscriber.

GUIDED MISSILE ENGINEERING. Edited by A. E. Puckett and Simon Ramo. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 497 pages 6¼ by 9¼ inches, bound. $10. The basic principles and engineering techniques of various scientific fields are reviewed with particular emphasis on their application to guided-missile design. Various sections of the book cover such fields as guidance theory, aerodynamics, electronics, airframe performance, computer systems, radio and radar, and flight simulators. Systems engineering aspects are stressed throughout the book, which attempts to place in perspective the relationships between specialized fields and over-all missile design.

HALBLEITERPROBLEME, Band III, 1956, 279 pages; Band IV, 1958, 381 pages. Edited by Walter Schottky. Friedrich Vieweg & Sohn, Braunschweig, West Germany. 6½ by 9¼ inches, bound. 36.80 and 46.80 DM. Each of these two volumes contains seven extensive papers on various aspects of semiconductors. These papers cover both theoretical and practical subjects, for example: surface properties of germanium and silicon, p-n photoelectric effect, plastic deformation of semiconductors and effect on electric properties, utilization of thermoelectric power of semiconductors; properties and application of silicon carbide, development and application of transistors, and kinetics of photoconductivity. One paper on electron and ion motion in oxide cathodes is in English, the others have brief English summaries. These papers were given at the 1956 and 1957 meeting of the Halbleiterausschuss of the Verband Deutscher Physikalischer Gesellschaften.

INTRODUCTION TO NEUTRON PHYSICS. By L. F. Curtiss. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J., 1959. 380 pages, 6¼ by 9¼ inches, bound. $9.75. Emphasizing experimentally demonstrated facts and the methods by which data was obtained, the author starts with the history of the evidence for the neutron's existence, and its reactions with other particles. He continues with a discussion of sources and detection of neutrons, spectrometers and monochromators, and the interactions of neutrons with matter. A review of calibration and standards, and a detailed chapter on shielding and protection of personnel is given.

LEXIKON DER HOCHFREQUENZ-, NACHRICHTEN- UND ELEKTROTECHNIK. Edited by Curt Rint. Verlag Technik, Berlin, Germany, 1957. 2 volumes (A-D, E-J), 5 by 8 inches, bound. 28.75 DM. for 2 volumes. This is an encyclopedic polyglot dictionary of high-frequency, communication, and electrical engineering terms. In addition to giving the corresponding terms in German, Russian, English, and French, brief explanations in German are provided, with illustrations, tabular data, and mathematical equations in some instances. So far, two volumes have been published covering A to J, and totaling over 1,600 pages. The basic arrangement is alphabetical by the German terms, but the final volume of this extensive work is to be an index of all terms in the other three languages.

DER LICHTELEKTRISCHE EFFEKT UND SEINE ANWENDUNGEN. By H. Simon and R. Suhrmann. Second edition. Springer-Verlag, Berlin, Germany, 1958. 747 pages, 6½ by 9¼ inches, bound. 97.50 DM. This treatise on the photoelectric effect and its applications deals with the following topics: photoemission and photoconductivity, external and internal photoelectric effects, design and construction of photoelectric cells, photoconductive cells and photo tubes, secondary emission electron multipliers, methods and equipment for photoelectric measurements, and a variety of applications. Over 1,500 literature references are cited.

MANUAL ON ROCKETS AND SATELLITES, Edited by L. V. Berkner. Pergamon Press, Inc. 122 E. 55th St., New York 22, N. Y., 1958. 508 pages, 7½ by 9¾ inches, paper. $25. Inasmuch as the techniques for exploring the environment by means of rockets and satellites are so recent, this manual takes the form of a series of scientific papers derived from the best of the scientific literature available, selected to provide a guide for those who will make observations in the field or conduct theoretical or experimental activities. The manual is broadly broken down into sections containing papers based on the IGY rocket program and the IGY earth satellite program, and in addition contains an extensive bibliography. A wide variety of aspects pertinent to each area is included such as telemetry, meteorology, radiation, and vehicles. The book constitutes Volume VI of the Annals of the International Geophysical Year.

MATRIX ALGEBRA HANDBOOK FOR ELECTRICAL ENGINEERS. By E. E. George. Ebasco Services, Inc.; distributed by E. E. George, 5108 Stonewall Road, Little Rock, Ark., 1958. 234 pages, 9½ by 11½ inches, ring binding. $7.50. The book discusses determinants, special matrices, matrix algebra operations and formulas, reduction of large matrices, elements of electrical matrices and the matrix solution of electrical networks, matrix algebra for digital computers, and the matrix determination of equivalent networks. The circuit problems used for illustration are of the types encountered in power-flow studies, fault-current determination, and stability problems in an electric power system.

METAL RECTIFIER ENGINEERING. By E. A. Richards. Sir Isaac Pitman and Sons, Ltd., London, England, 1958. 209 pages, 5¾ by 8¾ inches, bound. 37s 6d. The information given is presented in such a way that it may be applied to the design of metallic rectifiers of any type. Among those aspects treated are construction and characteristics, rectifier losses and efficiencies, electrical and mechanical design of stacks, transformers for use with rectifiers, rectifier harmonics and smoothing, and methods of voltage control.

MOBILE RADIO TELEPHONES. By H. N. Gant. The Macmillan Company, 60 Fifth Ave., New York 11, N. Y., 1959. 125 pages, 5¾ by 8¾ inches, bound. $4.50. The uses of mobile radio telephones are discussed from a commercial point of view. The author explains the terms and specifications likely to be encountered in manufacturers' literature and their effect upon the performance of equipment. Given this information, the best installation can be selected for a given situation. In addition, the problems involved in installation, maintenance, and testing are considered.

NUMERICAL ANALYSIS AND PARTIAL DIFFERENTIAL EQUATIONS. By G. E. Forsythe and P. C. Rosenbloom. John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1958. 204 pages, 6 by 9¼ inches, bound. $7.50. The first portion of the book deals with recent developments in numerical analysis, which is viewed by the author as a means of devising and evaluating numerical techniques for computers. Emphasis is placed on Soviet contributions to this field. The second part studies the work which has been done in linear partial differential equations since 1953. Methods are given which are applicable to wide classes of equations, and in most cases results are stated in the form of definite theorems for the sake of easy reference. This is Volume V in "Surveys in Applied Mathematics."

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The Library also prepares bibliographies, maintains search and translation services, and can supply a photoprint or a microfilm copy of any item in its collection. Address inquiries to R. H. Phelps, Director, Engineering Societies Library, 29 W. 39 St., New York 18, N. Y.

PULSE AND TIME-BASE GENERATORS. By D. A. Levell. Sir Isaac Pitman and Sons, Ltd., London, England, 1958. 175 pages, 5 by 7½ inches, bound. 25s. A concise survey is presented of the theory and design of circuits used to generate pulse and time-base waveforms for such applications as radar, television, and electronic instrumentation. The book is divided into sections dealing with linear circuits, nonlinear circuits, pulse modulators, trigger circuits, electromagnetic time-bases, and transistor circuits. The chronological order of development as well as the practical limitations of many circuits are given in detail, and an extensive bibliography is given to assist those who wish to refer to original papers for more detailed information.

RADIATION HAZARDS AND PROTECTION. By D. E. Barnes and Denis Taylor. Pitman Publishing Corporation, 2 W. 45th St., New York 36, N. Y., 1959. 178 pages, 5¾ by 8¾ inches, bound. $6.75. The nature of the radiation hazard is explained and the levels of radiation which are accepted as safe are presented. The authors discuss the protective methods by which these safe levels can be attained, and the measurements that will show whether satisfactory conditions have been achieved. In a concluding section, the radiological hazards arising from atomic warfare are examined, together with the protective measures possible. A considerable portion of the book is devoted to various types of instrumentation.

RADIOISOTOPES IN SCIENTIFIC RESEARCH. Volume I: Research with Radioisotopes in Physics and Industry, 761 pages; Volume II: Research with Radioisotopes in Chemistry and Geology, 741 pages. Proceedings of the First (UNESCO) International Conference. Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y., 1958. 6½ by 10¼ inches, bound. $22.50 each. Volume I considers research with radioisotopes in physics and industry and contains papers discussing production of radioisotopes, dosimetry, design and use of strong sources, metallurgy, industrial applications, solid-state physics, and methods and techniques. Volume II considers research with radioisotopes in chemistry and geology and contains papers dealing with organic chemistry, recoil chemistry, analytical chemistry, physical chemistry, geophysics, and production of radioisotopes.

REFLEX KLYSTRONS. By J. J. Hamilton. The Macmillan Company, 60 Fifth Ave., New York 11, N. Y., 1959. 260 pages, 5¾ by 9 inches, bound. $9. This is an introductory survey of reflex klystrons. The author discusses cavity resonators and output systems, electron dynamics of the reflex klystron oscillator, load effects, engineering aspects, representative and unconventional reflex klystrons, and future trends. The practical aspects of reflex klystron manufacture are emphasized throughout, and descriptions of the physical processes occurring in actual tubes are given.

RELIABLE ELECTRICAL CONNECTIONS. Proceedings of the Third EIA Conference, 1958. Published by Engineering Publishers, P. O. Box 1151, New York 1, N. Y., 1958. 286 pages, 6 by 9¼ inches, bound. $7.75. The latest developments in the design and application of electrical connections are discussed. The results of investigations are given in 32 papers dealing with fixed connections, disconnect connections, soldered connections, pressure connections, wire-wrap connections, and welded and ultrasonic connections. Several papers cover aspects of connections in relation to printed circuits.

SEMICONDUCTOR ABSTRACTS. Volume IV, 1956 issue. Compiled by Battelle Memorial Institute. John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1959. 456 pages, 8½ by 11 inches, bound. $12. This volume, covering the literature of 1956 and some of 1955, has been expanded by the inclusion of abstracts of unpublished papers presented at meetings of the American Physical Society and the Electrochemical Society. Abstracts are arranged by subject area and cover germanium; silicon; carbon, selenium,

and other elemental semiconductors; intermetallics; sulfides, selenides, and tellurides; oxides; halides; organics; and theory. An author and subject index is provided.

SOLID STATE PHYSICS: ADVANCES IN RESEARCH AND APPLICATIONS. Volume 7. Edited by Frederick Seitz and David Turnbull. Academic Press, Inc., 111 Fifth Ave., New York 3, N. Y., 1958. 525 pages, 6 by 9¼ inches, bound. $12. Among those aspects of solid-state physics reviewed in the present volume are thermal conductivity and lattice vibrational modes, electron energy bands in solids, the elastic constants of crystals, wave packets and transport of electrons in metals, study of surfaces by using new tools, and the structure of crystals.

THE THEORY AND DESIGN OF MAGNETIC AMPLIFIERS. By E. H. Frost-Smith. Chapman and Hall, Ltd., London, England; John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1958. 487 pages, 5¼ by 9 inches, bound. 75s. Practical design techniques are combined with theory in this survey of transductors and magnetic amplifiers. Those aspects discusssed include transient and steady-state operation of idealized transductors, self-excited and auto-excited transductors, closed-loop control systems, transient and frequency response of transductors, high-speed transductors and magnetic amplifiers, balanced magnetic amplifier circuits, low level amplification and multistage amplifiers, and magnetic modulators.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

NEMA STANDARDS. The following NEMA Standards Publications are available for immediate distribution: Identification of Covered Arc-Welding Electrodes, EW 2-1959, 75¢; Quick Connect Terminals, DC 2-1959, no charge; Air-cooled and Hydrogen-cooled Synchronous Condensers, LG 1-1958, 30¢; Large Generating and Converting Apparatus, LG 2-1958, 30¢; and Molded Case Breakers, AB 1-1959, 40¢. Motors and Generators, MG 1-1959, available at $10 per copy, is a revised book which contains 14 parts dealing with such aspects as definite-purpose motors, synchronous motors, motor-generator sets, etc. Up-to-date information concerning new publications or revisions of existing publications may be secured by writing to NEMA, 155 E. 44th St., New York 17, N. Y. A copy of "Your Guide to NEMA Standards Publications," which contains a short description of each book, is available upon request.

FEDERAL AVIATION AGENCY, RESEARCH AND DEVELOPMENT PROGRAM AND PROGRESS REPORT, November 1958. This is a summary report on research and development programs directed to modernization of the national system of aviation facilities, and of the progress made since establishment of the Airways Modernization Board, from Aug. 14, 1957, to Nov. 1, 1958, when all functions of the Board were transferred by Executive order of the President to the Administrator, Federal Aviation Agency, and the organization was renamed Bureau of Research and Development, Federal Aviation Agency. The report discusses each of the 306 projects and tasks, established during the 14-month period, which were assigned to the Bureau's four technical Directorates. Copies of the report may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at 70¢ per copy.

ECPD PUBLICATIONS. Three new brochures to guide young engineers after graduation have been made available by the Training Committee of the Engineers' Council for Professional Development (ECPD). *Your First Five Years* outlines the challenge to the young graduate, cites several guiding principles, and suggests a 6-point professional development program. Price is 10¢. *Selected Reading for Young Engineers* contains a recommended reading list with suggestions in a wide variety of fields from economics and sociology to general literature. Price is 15¢ each; quantity discount on request. *Personal Appraisal* questionnaire is designed to aid the young engineer in evaluating his progress periodically so that he may effectively plan his steps in future professional development. Price is 10¢ each. All three are available as separate items or will be furnished with each purchase of the basic reference manual, *A Professional Guide for Young Engineers*, which contains "The Second Mile" papers of W. E. Wickenden, and a statement of the "Canons of Ethics for Engineers," and the "Faith of the Engineer." Total cost of the Guide and brochures is $1. They may be ordered from ECPD, 29 W. 39 St., New York 18, N. Y.

NUCLEAR REACTOR PLANT DATA—RESEARCH AND TEST REACTORS. This book contains detailed information on 95 reactors in the United States, Canada, South America, Western Europe, and Asia. Information listed for each reactor includes type, designer, operating schedule, cost, status, fuel, coolant, control, research facilities, bibliography, and a detailed diagram of the reactor. All data was prepared under the supervision of the Nuclear Engineering Division of The American Society of Mechanical Engineers (ASME). The 297-page book is available from the Order Department of ASME, 29 W. 39 St., New York 18, N. Y., at $7.50.

THE SCIENTIFIC REVOLUTION, Challenge and Promise. Based on the conference held in 1958 at Yale University on "America's Human Resources to Meet the Scientific Challenge," sponsored by the President's Committee on Scientists and Engineers, the volume presents the papers of the participants in seven selections: America in an Age of Science, The Soviet Challenge, Developing an Adequate Science Program, Public Understanding of the Scientist, Forty Million Growing Minds, The Coming Crisis on Campus, and The Education and Use of Superior Talent. The 280-page book was published by Public Affairs Press, 419 New Jersey Ave., SE, Washington 3, D. C. Price is $6.

RESEARCH HIGHLIGHTS OF THE NATIONAL BUREAU OF STANDARDS, Annual Report, Fiscal Year 1958. This report highlights research and development programs carried out by the Bureau during fiscal 1958. It describes a wide range of scientific studies, laboratory experiments, instrument developments, and technical publications, all of which were undertaken with the basic aim of improving the measurement sciences. Some of the areas dealt with in the report are: electricity and electronics, optics and metrology, heat, atomic and radiation physics, chemistry, cryogenic engineering, radio propagation, and basic instrumentation. The pamphlet, 45¢, is sold by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D. C.

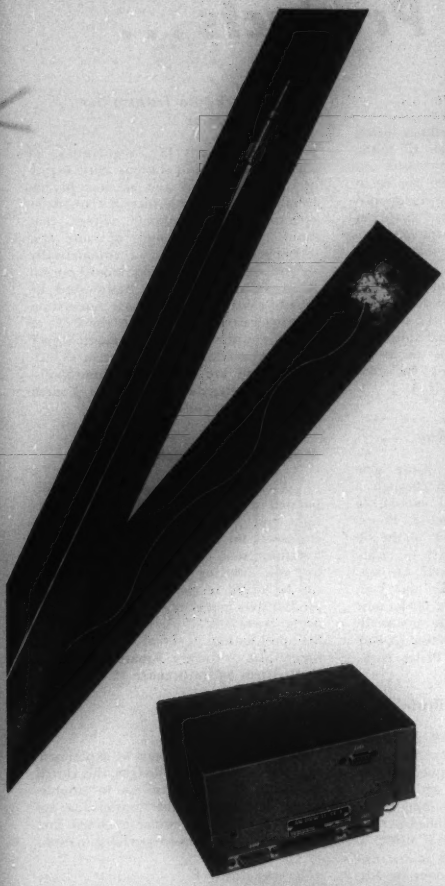
BIBLIOGRAPHY ON SHELL MOLDING. This is a selected list of over 200 annotated references to books, reports, and magazine articles published from 1952 to 1958, covering all aspects of shell molding, including theory, principles, production practice in large and small ferrous and nonferrous foundries, materials, design, testing methods, equipment, and costs. There are papers on the application of shell molding to the manufacture of crankshafts and other automotive parts, waveguides, heaters, electric motor parts, gears, seal rings, valves, pipe flanges, bells, etc. This "ESL Bibliography No. 13" may be purchased from the Engineering Societies Library, 29 W. 39 St., New York 18, N. Y. Price is $2.

PROCEEDINGS OF THE 5TH ANNUAL COMPUTER APPLICATIONS SYMPOSIUM, 1958. The objective of the symposium, sponsored by Armour Research Foundation, was to provide a medium for discussing the applications of computer technology from the standpoint of the user. Business and management applications were emphasized on the first day and engineering and scientific applications on the second day. The sessions of the symposium stressed the use of new computers and accessories, new techniques of computer programming, the organization and operation of computer installations, and new applications. Included in this publication are the pertinent discussions which followed the scheduled talks in addition to the panel discussion which climaxed each day's session. The proceedings may be ordered from Armour Research Foundation of Illinois Institute of Technology, MF: CA 5, 10 W. 35 St., Chicago 16, Ill. Price is $3 per copy.

ATOMIC INDUSTRIAL PROGRESS AND 2ND WORLD CONFERENCE, 1958. In its 25th semiannual report to the Congress, the Atomic Energy Commission (AEC) includes: Part I, a summary of industrial atomic progress during 1958; Part II, a description of United States participation in the 2nd World Conference on Peaceful Uses of Atomic Energy; and Part III, the customary semiannual review of major activities in selected atomic energy programs, July to December 1958. Several appendixes provide data and detail on the various programs. The report may be purchased at $1.25 from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

IF IT HAD BEEN A SNAKE. Seldom, if ever, is a novel reviewed in these columns, but the departure from custom seems justified by the thought-provoking dialogue of this book, written by M. J. Willner. Many novels have been written about lawyers, physicians, clergymen, and researchers in scientific fields; this one brings to light another professional—the electrical engineer. Lloyd Fraser is a poor Florida farm boy who has chosen Georgia Tech for a start on his electrical engineering career. He is at first bewildered by the mass of trivia which overwhelms him and the grinding study he must undertake. Matured by his 3 years in the World War II Army, he is prepared for anything that his professors might throw at him. He works hard and plays hard; he finds that women are an enigma; and he feels something is lacking in his education. These facts are brought out in intelligently written "bull sessions" among his fellow students. We travel with Fraser to his first job at a California Aviation plant, where he meets his first disillusionments and the realization that working with people is equally important as engineering knowledge. From California, he goes to a better job near New York and broader fields. The author, an electrical engineer himself, has made Fraser a completely understandable human being, whether venturing into the wherefores of sex with Georgia "peaches" during his school days; questing as a young bachelor about town; or reacting to the various individuals he meets in the jungle of the engineering business. Above all, he thinks for himself, as evidenced in a climacic moment. "The answer was so simple. Why couldn't I have thought of it then, when I needed it? My God—the solution was so close! If it had been a snake, it would have bitten me!" Here is a novel which should hold an electrical engineer's interest whether he is just graduating from school (it will open his eyes to what lies ahead) or he has been through the mill (it will bring back the times when he worked for "peanuts"). This book should interest those thinking men who are responsible for giving fledgling electrical engineers their educational backgrounds in college and those supervisors who are guiding the recent graduates in their first engineering jobs. The 407-page bound book was published by Vantage Press, Inc., 120 W. 31 St., New York, N. Y., 1959, and is available at $5.

CHARACTERISTICS TABULATIONS. Three periodicals which catalog electronic components are being published by Derivation and Tabulation Associates, Inc. (D.A.T.A.). The *Semiconductor Diode & Rectifier List* is issued semiannually at $25.25 per year; *Microwave Tube Tabulation* is issued semiannually at $15.50 per year; and *Transistor Characteristics Tabulation* is issued quarterly at $15.50 per year. All three utilize the characteristic symbols consistent with those recommended by the IRE and AIEE. All data for the current types have been completed from specification sheets and special information supplied by manufacturers. Further details on subscription may be obtained from D.A.T.A., 67 Lawrence Ave., West Orange, N. J.



COMMAND DESTRUCT

The flight testing of second generation missiles—more versatile and powerful than their predecessors—requires a device for sure termination of any missile flight that might endanger the test range or surrounding area.

Ramo-Wooldridge engineers, under a United States Army Signal Corps contract, have successfully developed and delivered the first sub-miniature, completely transistorized radio "command destruct" receivers.

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Compact and rugged, the radio receiver's modular construction permits rapid and complete accessibility to all components. One module houses the basic receiver. The second module contains the three command channels and relays. This integrated package occupies 115 cubic inches, and weighs 4 pounds. The receiver requires no pressurization and operates reliably under the adverse environmental conditions encountered in missile flight testing.

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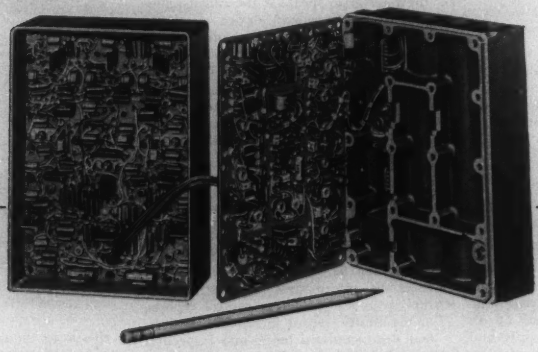

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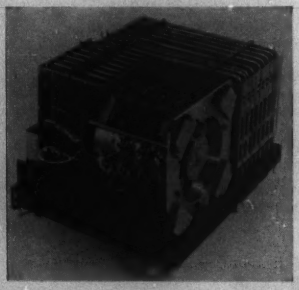
Airborne Digital Computer . . .

Silicone-transistorized throughout, the new *AN/ASN-24* multifunctional computer weighs only 32 pounds, occupies a mere 950 cubic inches, yet it contains a 6,000-rpm memory drum capable of storing 2,048 words and the logical-computing



faculty for accepting automatically or manually 12 or more different sources of navigational data input for trigger-quick solution to the basic problems of: "Where am I?" "What is the best way to get to my destination?" and "How far is it?" **Librascope Inc., Glendale, Calif.**

Remote Time Displays . . .

A digital clock supplying exact time displays similar to those used at missile launching and nuclear test sites to establish precise timing information at a number of control locations consists of six decade counters with power supply and a selector switch for each decade to allow presetting of time. Each display consists of six Nixie electronic readout tubes which provide indication of real time in hours, minutes, and seconds. **Burroughs Corp., Electronic Tube Division, Plainfield, N.J.**

New Recessed Luminaire . . .

Made for all types of ceilings including the inverted "T," "Z," and "H" spline, and for ordinary or acoustical plaster ceilings, this new series No. 6400 can be integrated with a variety of contemporary interiors. One style employs a prism-border, a new lighting concept of a lens with a shallow dropped edge that projects light on the ceiling. The other features a flat lens for unbroken ceiling surfaces. Total luminosity throughout is achieved by concealed reinforced ribs, and the emitted light is carefully controlled by sharp cone prisms molded in the acrylic plastic lens. **Holophane Co., Inc., 342 Madison Ave., New York 17, N. Y.**

Lightweight Portable X Ray . . .

A 50-pound industrial X-ray generator, small enough to pass through a 6-inch opening yet powerful enough to radiograph 1¼ inches of steel in 45 seconds, was designed for quick on-the-job inspections by one man. Used to radiograph pipelines, pressure vessels, castings, aircraft, missiles, storage tanks, tank cars, ships, and the like, the Andrex 140-kv unit can be operated on practically any available power supply line. **Picker X-Ray Corp., 23 S. Broadway, White Plains, N. Y.**

Intercom Phone with a "Brain" . . .

Designed to speed inter-office contact between top executives and key staff members whom they call most frequently, this intercom phone initiates calls without lifting the receiver or dialing by simply pushing a line button. When the called party's phone rings and the receiver is lifted, a ready signal buzz-back sounds in the executive's set and only then does he lift the receiver to speak. If the called phone is busy, a "memory" device seizes the switchboard circuit and automatically completes the call when the line is free. During this interval, no other calls can be originated or received by the busy phone. If desired, cut-in privilege may be exercised by pushing the same button a second time. **Tele-Norm Corp., 55 W. 42 St., New York 36, N. Y.**

Read-Out Form Printer . . .

This desk printer with a 12-decade capacity and an automatic preprinted form ejector can be used to record automatic check-out information, log instrumentation data, record quality control reports, automatically record inspection records, and print gummed labels and inspection tags. Printing data sources may include digital volt meters, shaft position transducers of both the decimal and coded types, Eput meters, electronic counters, step switch banks, and relay banks. **Clary Corp., 408 Junipero St., San Gabriel, Calif.**

Automatic Radio Transmitter Logger–Monitor . . .

Under present FCC regulations, all radio and television stations must manually log transmitter and antenna parameters to determine variance in transmitter operation. This elecronic system, that monitors the performance of radio and television transmitters and automatically records what is happening, would permit radio stations to operate transmitters by remote control. The National Association of Broadcasters will petition the FCC to authorize industry use of automatic logger records as official transcripts when experimental tests are completed. **Minneapolis-Honeywell Regulator Co., 2954 Fourth Ave. S., Minneapolis 8, Minn.**

Manual Starter Lock . . .

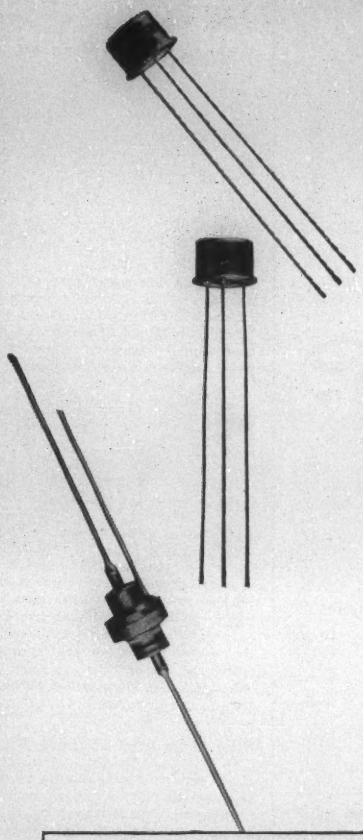
A new lock-off device has been incorporated in Square D's NEMA type 4 watertight and NEMA type 12 industrial-use enclosures for manual starters. By sliding a stainless steel plate over the "Start" button and inserting a padlock, the starter can be locked in the "Off" position. The pushbuttons are recessed to prevent accidental operation. Silicon rubber boots over the pushbuttons prevent the entry of water, dust, or coolant. **Square D Co., 4041 N. Richards St., Milwaukee 12, Wis.**

Magnetic Clutch . . .

Developed after 3 years of experimentation with 27 different designs, this clutch is said to be a new concept in trouble-free power control and transmission applications. This is because a closed flux path through hardened steel laminations

eliminates the need for adjusting air gaps and a stationary magnetic field, with coil windings on the stator instead of the rotor, eliminates slip rings and brushes. **I-T-E Circuit Breaker Co., 1900 Hamilton St., Philadelphia 30, Pa.**

(Continued on page 20A)



How to get ultra-uniformity

in a Silicon PNP fused alloy transistor

Through precise manufacturing techniques, Hughes PNP fused-junction silicon transistors give you extreme uniformity of parameters by type. Result: circuit interchangeability no longer is a problem.

Designed for switching and amplifying applications at low and medium current levels, these Hughes transistors offer you a number of advantages:

- useful Beta at extremely low collector currents
- BV_{EBO} and BV_{CBO} are similar
- high punch-thru voltage (BV_{CEO} in excess of 100 volts in types 2N1244 and 2N1234)
- low saturation resistance

These E.I.A. registered devices, now available in production quantities, are housed in TO-5 (single ended) and coaxial packages (double ended). Engineered for extreme reliability, several types meet MIL-T-19500A specifications.

Coaxial Package Type:	2N1238	2N1239	2N1240	2N1241	2N1242	2N1243	2N1244
TO-5 (formerly JETEC-30) Package Type:	2N1228	2N1229	2N1230	2N1231	2N1232	2N1233	2N1234
Collector to Emitter Voltage (BV_{CEO}) (I_{CEO}=100μA)	15V	15V	35V	35V	65V	65V	110V
Collector to Base Voltage (BV_{CBO}) (I_{CBO}=100μA)	15V	15V	35V	35V	65V	65V	110V
Emitter to Base Voltage (BV_{EBO}) (I_{EBO}=100μA)	15V	15V	35V	35V	65V	65V	110V

Coaxial Package: Power dissipation . . . 1 watt in free air (derate 7.4 mw/°C)
5 watts with heat sink (derate 37 mw/°C)

TO-5 Package: Power dissipation . . . 250 mw (derate 1.8 mw/°C)

Collector current limited by power dissipation. Operating and storage temperature range −65°C to +160°C

Your inquiry regarding these transistors will be given prompt attention. Just write or call the Hughes sales office nearest you. They are located in Boston (phone WO 2-4824), Newark (phone MA 3-3520), San Francisco (phone DA 6-7780), Syracuse (phone GR 1-0163), Philadelphia (phone MO 4-8365), Chicago (phone NA 2-0283), and Los Angeles (phone OR 8-6125). Or write Marketing Department,

SEMICONDUCTOR DIVISION, NEWPORT BEACH, CALIFORNIA

Creating a new world with ELECTRONICS

HUGHES PRODUCTS

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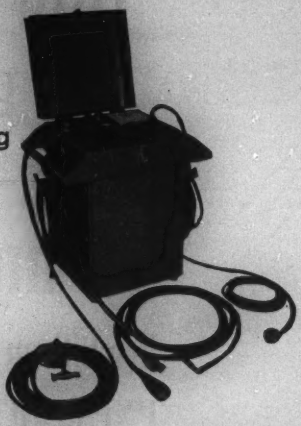
SEMICONDUCTOR DEVICES • STORAGE AND MICROWAVE TUBES • CRYSTAL FILTERS • OSCILLOSCOPES • RELAYS • SWITCHES • INDUSTRIAL CONTROL SYSTEMS

BIDDLE IMPULSE CABLE FAULT LOCATING EQUIPMENT

...for locating cable faults by impulse tracer method

...for D-C proof testing



This instrument consists of a high voltage d-c impulse transmitter with pickup coil and pointer-indicating detector. Designed primarily for locating faults on lead-covered cable installed in ducts, this equipment has applications also on aerial and buried cable, and has proved highly effective in utility and industrial service.

The transmitters require only 600 va input power at 115 v, 60 cps supply voltage and therefore can be connected to a lighting system.

MODEL 3-2 FAULT LOCATOR

Transmitter and output voltage up to 25 kv—Discharge capacitance 1.65 muf. Provided with three-range milliammeter for measuring insulation current when proof testing cable or other insulation. For use on cable up to 15 kv rating.

MODEL 4-2 FAULT LOCATOR

Transmitter output voltage up to 15 kv—Discharge capacitance 2 muf. For use on cable up to 5 kv rating.

MODEL 5-2 FAULT LOCATOR

Transmitter output voltage 5 kv—Discharge capacitance 16 muf. For use on cable up to 1 kv rating. All fault locators can be used on cable with higher voltage rating if fault conditions are favorable.

WRITE FOR BULLETIN 65-EE

B-811

JAMES G. BIDDLE CO.

• ELECTRICAL TESTING INSTRUMENTS
• SPEED MEASURING INSTRUMENTS
• LABORATORY & SCIENTIFIC EQUIPMENT

1316 ARCH STREET
PHILADELPHIA 7, PA.

New & Improved Products

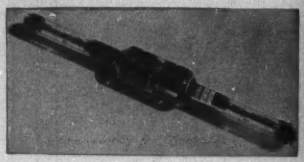
(Continued from page 18A)

Synthetic Sapphire Windows . . .

It is now possible to produce synthetic sapphire windows up to 5 inches in diameter in large contoured shapes for use in infrared, ultraviolet, and microwave applications. These windows combine outstanding qualities of wide-band electromagnetic transmission with hardness and strength at elevated temperatures. **Linde Co., Div. of Union Carbide Corp., 30 E. 42 St., New York 17, N. Y.**

Dual-Gun Storage Tube . . .

The *QK-703* cathode-ray recording storage tube was designed to scan-convert conventional radar scope patterns into composite television signals for viewing on an



ordinary television receiver. It is also applicable to slow-down video systems, making it possible to transmit television or radar pictures over commercial telephone lines for display and analysis at any point where radar information is needed. **Raytheon Mfg. Co., Microwave & Power Tube Div., Waltham 54, Mass.**

Plug-In Reactor Controls . . .

Compact nuclear "building-block" control modules may be grouped readily into "customized" systems to meet the individual requirements of virtually any type of reactor or operating need. They are supplied in four basic control channels: pulse channels to measure the rise of neutron flux from source levels to the intermediate power range; log N or intermediate channels to monitor and control rate of change of flux levels to full power; linear-servo channels to change power levels smoothly from one to another; safety-channels with load-sharing features which eliminate problems of false scrams but still provide utmost protection. **Leeds & Northrup Co., 4907 Stenton Ave., Philadelphia 44, Pa.**

Miniature Crystal Clock . . .

Awarded the Certificate of Excellence by the Miniaturization Awards Committee, this frequency and time standard unit is less than 5 inches high, contains 15 transistors, operates on 1.25-volts d-c, has an accuracy of 1 to 2.10^{-8} over a 24-hour period, and can be operated independently from an outside power supply by virtue of its solar-cell power elements. **Patek Philippe and Co., Geneva, Switzerland.**

(Continued on page 22A)

WHY SPACE IS
FRONT-PAGE NEWS . . .

Compact Clark Relays control 72 circuits from panel area smaller than a newspaper

In this day of space exploration and space economy, it's news—front page news—when you can get 72 separate, controlled circuits all on a panel no larger than 15" x 20".

Clark Controller, with the most complete and integrated line of control relays available today—convertible pole, latch, universal pole, and time delay—does it! And only Clark offers such a wide range of operation, so many contacts, in a panel area of such small size.

Shown mounted here with the Clark Size 1, Type "CY" Starter are 10 compact Clark Relays which include four time delay contacts (two normally open, two normally closed), 52 instantaneous contacts (14 normally open, 14 normally closed, and 24 convertible), plus 16 latching contacts (all convertible).

The same engineering leadership and superior workmanship that made Clark Controller the *standard of quality* for controls in heavy industry, is inherent in the broad line of Clark Relays for modern panels.

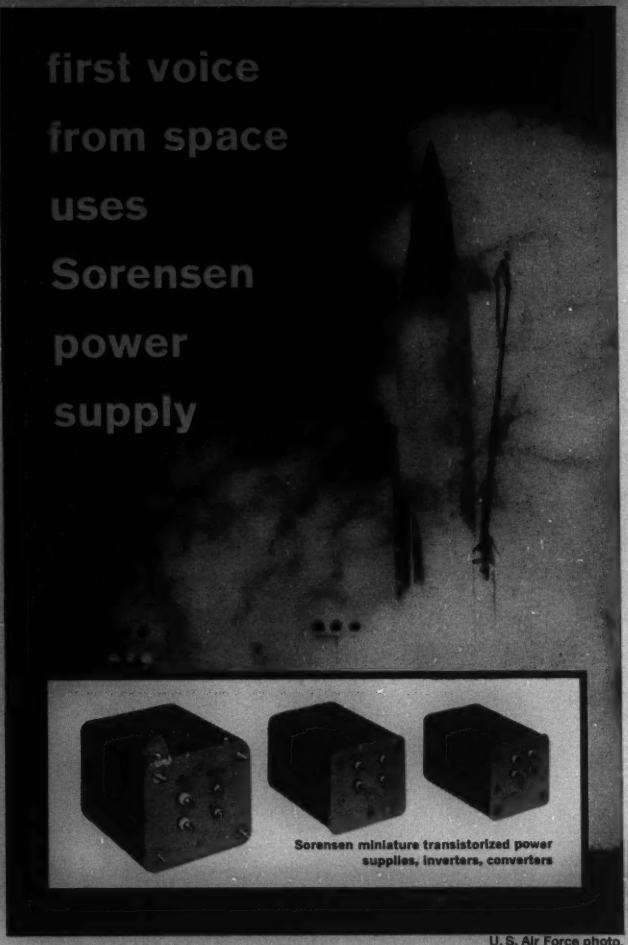
The "modular construction" of all Clark "PM" Relays insures integrated uniformity, compactness and flexibility. Functional alignment in mounting results in neater, more uniform panels and most efficient utilization of valuable space. And because "PM" relays are available in a wide variety of pole combinations, providing up to 14 contacts on a single relay, you can control more circuits—save on relay requirements.

For more information on the complete line of Clark "PM" Relays which is making space-saving headlines, contact your nearest Clark Controller sales office or distributor. Or, write direct to Clark Controller for free bulletins.

The
CLARK CONTROLLER
Company

Everything Under Control • 1146 E. 152nd St. • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO



U. S. Air Force photo.

Last December, a Christmas message from outer space heralded a new era in radio communications.

Coming from an orbiting, 80-foot-long U. S. Air Force Atlas missile, the voice was broadcast over U. S. Army Signal Corps designed communications equipment. We at Sorensen, are proud indeed that a miniature Sorensen transistorized power supply was selected as part of this communications equipment.

Transistorized supplies for every purpose. Sorensen manufactures a complete line of miniature transistorized power equipment including: highly regulated a-c powered d-c supplies, dc-to-dc converters and dc-to-ac inverters. They are rugged, compact and as simple to incorporate into your equipment as an ordinary transformer or other "potted" component. They are available in an extremely wide variety of input-output voltage combinations and current capacities. Write for complete data.

SORENSEN & COMPANY, INC.
Richards Avenue, South Norwalk, Connecticut
WIDEST LINE OF CONTROLLED-POWER EQUIPMENT FOR RESEARCH AND INDUSTRY

IN EUROPE, contact Sorensen-Ardag, Zurich, Switzerland. **IN WESTERN CANADA,** ARVA. **IN EASTERN CANADA,** Bayly Engineering, Ltd. **IN MEXICO,** Electro Labs, S. A., Mexico City.

New & Improved Products

(Continued from page 20A)

Subminiature Circuit Breaker . . .

An electrical circuit breaker, vacuum sealed in a glass envelope about the length of a common pin, provides protection by interrupting current flow when excessive current or external heating occurs. As temperature decreases or the overload is removed, the current path is automatically reset. Only 1⅛ inches long and ⅜ inch in diameter, the Mite T Breaker will have useful application in aircraft and automotive controls, computer equipment, business machines, vending devices, and similar products. **Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y.**

Thickness Gauge . . .

A new type of optical-electronic instrument measures thickness of sheet, foil, or webbing of any width and material by using a principle similar to the sighting of distant landmarks on the cross-hairs of surveying telescopes. Physical properties such as dielectric constant, conductivity, and absorption of radiation, are not involved in the measurement. The instrument is particularly suitable for quality control of paper, coated fabrics, or plastics and similar materials which do not lend themselves easily to indirect gaging methods. **Mark N Laboratory, Bethel, Conn.**

Automatic Message Relay Set . . .

This new unit, called the *28 RT*, is a high-capacity self-contained punched-tape message relaying facility for receiving wire signals at speeds ranging from 60 to 200 words per minute, converting them into perforations in paper tape, and transmitting them at the same or another speed to local or remote receiving stations. It is designed for a variety of uses in communications, data processing, and automation such as input–output speed converter, intermediate message storage unit, business machine–communications linkage, automatic data accumulator, and a control device for automated factory equipment. **Teletype Corp., 4100 Fullerton, Chicago 39, Ill.**

Recording Pyrometer . . .

An optical recording pyrometer that can measure extremely high temperatures with milliseconds response may be operated when conditions are hazardous to personnel. The radiation-sensitive element is a high-vacuum phototube. Monochromatic light of wavelength 0.65 micron is focused upon an opaque plate having a small opening that admits the radiant energy to the phototube. This output is then simplified and the resulting signal read on a meter or external recorder. **Avco Mfg. Corp., Research and Advanced Development Division, 201 Lowell St., Wilmington, Mass.**

Automatic Hardness Tester . . .

This machine checks parts for hardness using an electronic gaging system. Parts are automatically positioned on the conveyor where they are transferred one at a time to the hardness-checking penetrator. A standard minor load, which varies according to the scale being used, is applied and a clutch automatically sets the gauge at zero. Then a major load is applied. The depth of penetration causes voltage changes in a gauge head which are taken off and converted to a smoothly varying direct current proportional to the degree of hardness. This d-c voltage, when applied to a thyratron, actuates gates which classify the tested parts into categories after they have been discharged from the checking station. **Radio Corp. of America, Industrial & Automation Div., 12605 Arnold Ave., Detroit 39, Mich.**

Aluminum Hangers and Capacitor Blocks . . .

These lightweight hangers and blocks for 100-kvar capacitor units were designed for standard mounting dimension of 15⅛ inches. The single-unit hanger is a sturdy, one-piece welded structure that can be mounted on a pole, wall, or crossarm. The three-unit hanger can be readily assembled in the field for crossarm mounting. Factory assembled aluminum capacitor blocks for use with 100-kva units in open type banks at transmission, subtransmission, and distribution voltages are available in eight sizes ranging from 600- to 2,000-kvar capacities. **Line Material Industries, McGraw-Edison Co., Milwaukee 1, Wis.**

Commercial Programmers . . .

A new series of electrical programmers offers versatility in solving complex electrical switching problems. Designed for volume production in such applications as vending machines, appliances, automation controls, advertising displays, and industrial programming, these components will provide from one to eight single-pole double-throw snap-action switches and a wide range of cycle times set up during manufacture providing from 30 seconds to 24 hours per cycle. **A. W. Haydon Co., Waterbury, Conn.**

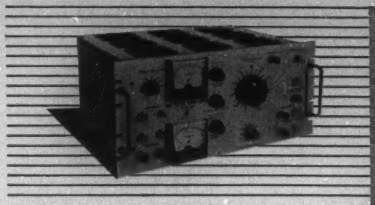
Battery Chargers . . .

Using new circuitry and hermetically sealed, nonaging silicon diodes, these single-phase Magnistrol chargers are designed for float charging battery installations ranging from 10 to 63 cells in five basic amperage capacities and in three voltage ranges. The units are readily adjustable for charging lead acid, nickel-alkaline, or nickel-cadmium batteries. Three-phase input chargers are also available for larger capacity installations. **Acme Electric Corp., 237 Water St., Cuba, N. Y.**

Wear Your ✦ AIEE Badge

NEW IDEAS IN PACKAGED POWER

for lab, production test, test maintenance, or as a component or subsystem in your own products



Series 1000.

Easy-to-use compact Beta Series 1000 high voltage supplies come in 13 different models, providing voltages up to 60kv dc and currents as high as 500 ma. Adjustable output voltage (0 to max. rating with coarse and fine controls); extremely low ripple; easy, rapid polarity reversal and full metering are a few outstanding features.

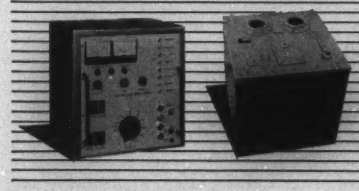
Single-unit, rack-mounting supplies to 60 KV

Available ranges and current capacities:

Output (DC KV)	Current (Max. MA)
0-1	500
0-3	200
0-5	10 or 100
0-10	2, 10, or 50
0-15	5, or 10
0-30	2, 5, or 10
0-60	5 @ 50 KV 1 @ 60 KV

Inputs: 117 vac, 60 cps, single phase

HV DC TO 250KV WITH MAXIMUM CONVENIENCE, SAFETY



Series 2000 — control section (left).
Series 2000 — high-voltage section (right).

Simple to operate, conservatively rated to insure long, optimum performance with maximum safety, Beta Series 2000 supplies come in thirteen different models, with maximum voltages ranging from 1 to 250kv dc. Output voltage continuously adjustable from 0 to maximum. Two-unit design allows optional remote operation of high voltage circuits. For maximum voltages less than 30 kv, the high-voltage unit is air-insulated; for higher voltages, oil-insulated (shipped dry). Every precaution is taken to insure personnel and equipment safety.

Two section supplies to 250KV

Available ratings:

Output (KV DC)	Current (Max. MA continuous)
0-1	3000
0-3	1000
0-6	500
0-10	200
0-20	150
0-30	30
0-30	100
0-50	10, 50
0-120	5
0-120	25
0-150	5
0-250	10

Inputs: 117 vac, 60 cps, single phase

Sorensen markets the widest line of controlled power equipment available today, including: Regulated a-c and d-c supplies, unregulated power supplies, frequency changers, inverters, and converters, SAMES electrostatic generators for regulated voltages up to 600 kv dc, voltage reference sources, high-voltage d-c overpotential testers and high-potential test equipment.

An exceptionally wide selection of standard models is available and experienced Sorensen engineers are always glad to discuss your special needs. 9.13

SORENSEN & COMPANY, INC.

Richards Avenue, South Norwalk, Connecticut

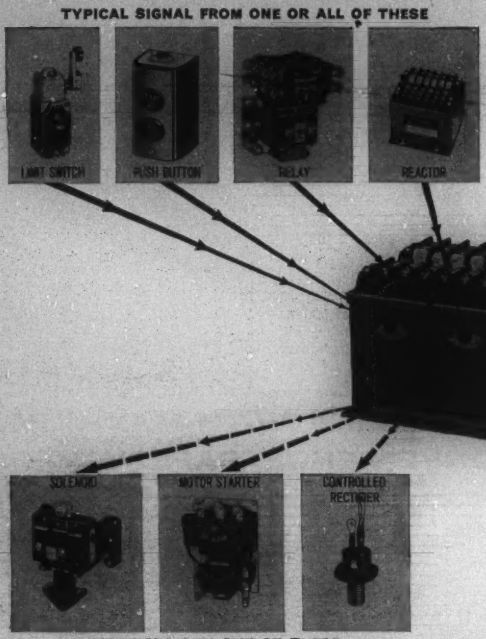
Sorensen

WIDEST LINE OF CONTROLLED-POWER EQUIPMENT FOR RESEARCH AND INDUSTRY

IN EUROPE, contact Sorensen-Ardag, Zurich, Switzerland. **IN WESTERN CANADA,** ARVA. **IN EASTERN CANADA,** Bayly Engineering, Ltd. **IN MEXICO,** Electro Labs, S. A., Mexico City.

JOURNAL OF APPLIED CONTROL DEVICES THAT NEVER WEAR OUT

For Control Engineers Who Are Wearing Out Before Their Time



STATIC CONTROL COMPLICATED?

DON'T YOU BELIEVE IT!

An engineering friend of ours working on blast furnace controls uses a CONTROL switching reactor to take signals from a series of limit switches, temperature controllers, and relays to operate the solenoid which triggers the air blast motor. Dollars ahead he was when he saw this *selective* device would take signals from many sources, compile them, remember them, and when told to act (by the same standard input signals), leap into action. "So simple," he said—"nothing but the standard inputs we always use, switching reactor and outputs. If that's static control, I'm the new president of the C.S.R* Booster Club." *You, too, can beat the drum. Write for our catalog about Simple Static Control.*

**CONTROL Switching Reactor*

PUSH, PULL, CLICK, CLICK *(or how to feed a switching reactor)*

Persons who hear push-pull-click-click sounds in industrial plants are not to be suspected of an affinity for the razor business. They are listening to the music of push buttons, limit switches and relays, all feeding signals into CONTROL'S switching reactors (which are engaged in static control). Our reactor is *selective*. As you dictate, it responds to control voltages which add, which oppose, or which work in combination, regardless of source. What's more, our reactor can be fed by a transducer whose output is electrical—even if it doesn't say "push, pull" or "click, click."

If you have an affinity for money-making musical sounds, perhaps you'd like to know more about these CONTROL switching reactors. Write us.

CLICK, CLICK, PULL, PUSH *(or how a switching reactor feeds you)*

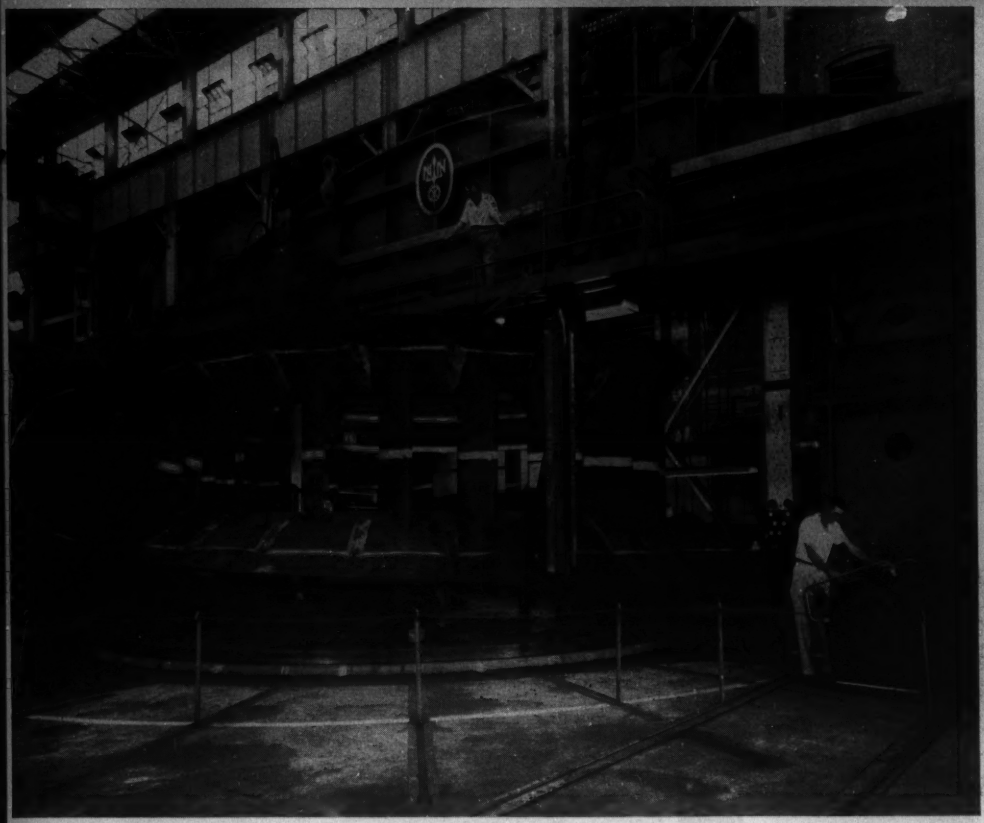
Here is the click-click-pull-push (output) side of the CONTROL switching reactor. Not only is it *selective* as to source and combinations of inputs, but it is a real bear for working such loads as solenoids, motor contactors and magnetic clutches. It shines, too, as a practical way of operating the new solid state thyratron from a variety of input sources. A reactor can control a single load up to 300-VA to a fare-thee-well. Loads are statically switched with nary a moving part. What's more, there is no auxiliary hardware (transformers, relays or single purpose logic units) to clutter the minds and hearts of your control engineers and purchasing agents.

Sizes? A complete range, including 15, 75, 150, and 300 VA. There's also one especially for the solid state thyratron. Why not write for more details about our CONTROL switching reactors.

Reliability begins with CONTROL

A DIVISION OF MAGNETICS, INC.

DEPT. EN-62, BUTLER, PENNSYLVANIA



42 ft. boring mill-rough cuts a stay ring for one of the world's most powerful hydraulic turbines.

Newport News builds six king-size turbines for Niagara Power Project

These skilled Newport News machinists are milling a stay ring for one of six 200,000 hp. Francis-type hydraulic turbines. Before they're finished, they'll turn out five more turbines—the world's most powerful—for the Lewiston Power Plant of the Niagara Project.

Newport News has not only the men, but the facilities to take a job like this in its stride . . . your job, too. For example, the 42 ft. boring mill pictured above was designed and built at Newport News.

The large engineering and technical staffs, acres of iron, brass and steel foundries, five huge machine shops, and additional specialized equipment make Newport News a leader in the production of hydraulic turbines, valves, gates, penstocks, and other water power equipment you need.

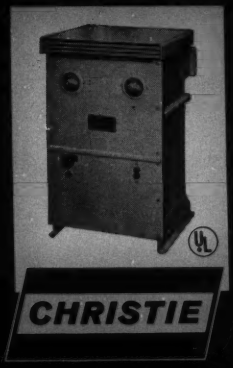
Consult Newport News engineers on preliminary design recommendations at no obligation.

Engineers . . . Desirable positions available at Newport News for Designers and Engineers in many categories. Address inquiries to Employment Manager.

Newport News
Shipbuilding and Dry Dock Company
Newport News, Virginia

D-C POWER

Precisely Regulated for Missile Testing and General Use



CHRISTIE

SILICON POWER SUPPLIES

available in 30 standardized and militarized models from 30 to 1500 amps... 6 to 135 volts. CHRISTIE'S QUALITY CONTROL is approved by the A.E.C., leading aircraft and missile manufacturers.

Write For Bulletin AC-58-A

CHRISTIE ELECTRIC CORP.
3410 W. 67th Street
Los Angeles 43, Calif.

Industrial Notes...

Radio Corporation of America
New York, N. Y...

The story of recorded sound from the tin foil cylinder to the stereo disk will be told to club groups throughout America as a public service of the Radio Corporation of America. A series of traveling presentation units, each consisting of a professional public speaker, a sound technician, and a station wagon full of old and new sound equipment, will appear before service, women's civic, and professional clubs in all parts of the nation during 1959. Club program chairmen may obtain available dates in their localities by contacting the RCA Shows and Exhibits Department, Camden 2, N.J.

Battelle Memorial Institute
Columbus, Ohio...

Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio, has plans for a new laboratory designed especially for studies of plutonium. The laboratory according to Dr. B. D. Thomas, president, is going up at the company's Nuclear Research Center, outside Columbus, Ohio. Scheduled to be in operation by midsummer, it will be a privately financed facility for the study of plutonium, generally conceded to be an important nuclear reactor fuel of the future. Research planned for the laboratory will center around applications of plutonium as a fuel in central station power reactors.

Simpson Electric Corp.
New York, N. Y...

Removal of Simpson Electric Corp. offices to new quarters at 1857-61 Second Ave., New York 28, N.Y., has been announced.

Acoustica Associates
Mineola, N. Y...

A completely new type of directional underwater sound source, which "fires" its beam of energy like a garden hose, has been developed for potential use in long-range detection of enemy submarines. The theory of an "End-Fire" underwater sound source has been proved feasible in model studies conducted by Acoustica Associates, 26 Windsor Ave., Mineola, L.I., N.Y., under the auspices of The Office of Naval Research. The novel underwater sound source is a long narrow tube which radiates a highly concentrated beam of energy from one end similar to the action of an ordinary garden hose squirting water. It has been found that this source is ideally suitable for application as an aircraft-towed directional transmitter-receiver, as an extremely directional and high-powered source operating at frequencies below 1,000 cps, and for a host of other potential uses in the field of underwater acoustics and antisubmarine warfare. Also, a new ultrasonic-type continuous liquid level or volume gauge, called "Ultrasonic Dipstick," has an accuracy unaffected by any characteristics of the liquid itself, according to the company.

Wiltec Electronics, Inc.
South Norwalk, Conn...

This company is now actively engaged in operations of all phases of special-purpose electron tube research, development, and production. The company located at 53 Water St., South Norwalk, Conn., is currently producing tubes for use in industrial and military devices, and their product list includes subminiature indicator thyratrons for transistor circuitry in computers, subminiature cold-cathode trigger tubes for electronic photoflash trigger circuits, and other special-purpose military applications.

Bell Telephone Laboratories
New York, N. Y...

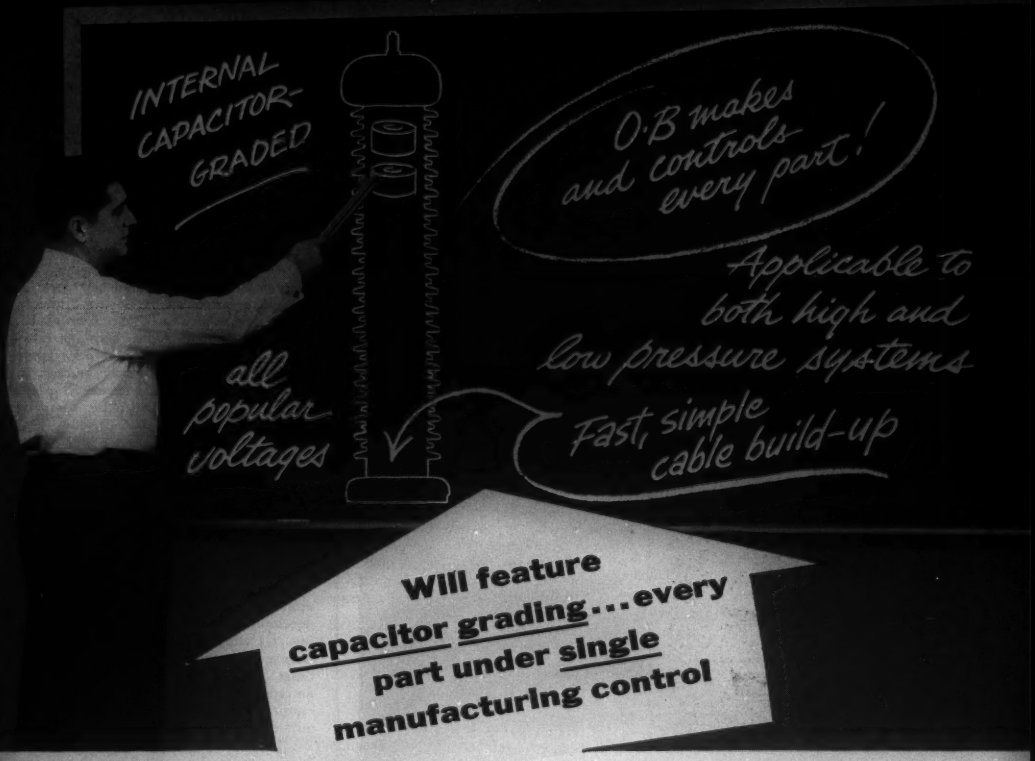
A $20 million modern laboratory is to be built by Bell Telephone Laboratories at Holmdel, N.J., to meet the expanding need for research and development to advance communications. The construction of the new building will be on a 430-acre site owned by Bell Laboratories at Holmdel since 1929. Buildings presently on the property provide working space for about 150 scientists, engineers, and staff studying high-frequency radio and electronics. The present Holmdel laboratory has been the site of many historic communications developments, over the past 3 decades, in radio telephony and ultra-short-wave propagation. Bell Telephone Laboratories, 463 West St., New York 14, N.Y.

Electronic Engineering Co.
Santa Ana, Calif...

An electronic device which permits one computer to "talk" to another is in operation at System Development Corp. located in Santa Monica, Calif. The Model *ZA-100* Computer Language Translator System, developed and built by Electronic Engineering Co., 1601 E. Chestnut Ave., Santa Ana, Calif., makes it possible for scientists and mathematicians to translate information from one computer or data processing system to another. Technically, the Model *ZA-100* will translate information from the Semi-Automatic Ground Environment (SAGE)System into IBM *709* data, or from IBM *709* data into Teletype transmissions, or from IBM *709* into various punch card formats.

(Continued on page 32A)

New O-B pothead coming


INTERNAL CAPACITOR-GRADED
all popular voltages
O-B makes and controls every part!
Applicable to both high and low pressure systems
Fast, simple cable build-up
Will feature capacitor grading... every part under single manufacturing control

Because of the definite need for a modernized design of capacitor-graded terminal for oil-filled cable, O-B is informing the industry of its new pothead development. This extension of a generation of pothead experience is now nearing the final stages of tooling for quantity manufacture.

New O-B potheads will be applicable to all popular makes of both low and high pressure cable systems. Voltage ratings will cover the entire range of present industry requirements, at 115 kv and above. Internal grading capacitors are an integral part of the assembly.

Cable build-up is greatly speeded and simplified. This not only saves installation time but minimizes the period of exposure of paper insulation to the air.

O-B is in the unique position of manufacturing all components. Total control is exercised over capacitor construction, paper winding and impregnation, porcelain production, and metal working. Every part is properly coordinated, and designed and built by men with a single interest and purpose.

If you are planning oil-filled cable installations, take advantage of this new development. Your O-B representative will gladly arrange to have the necessary information provided for you.

OHIO BRASS COMPANY, MANSFIELD, OHIO

Ohio Brass (B) HOLAN

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BUSHINGS · HOLAN TRUCK-MOUNTED POWER DEVICES AND BODIES · BRONZE VALVES

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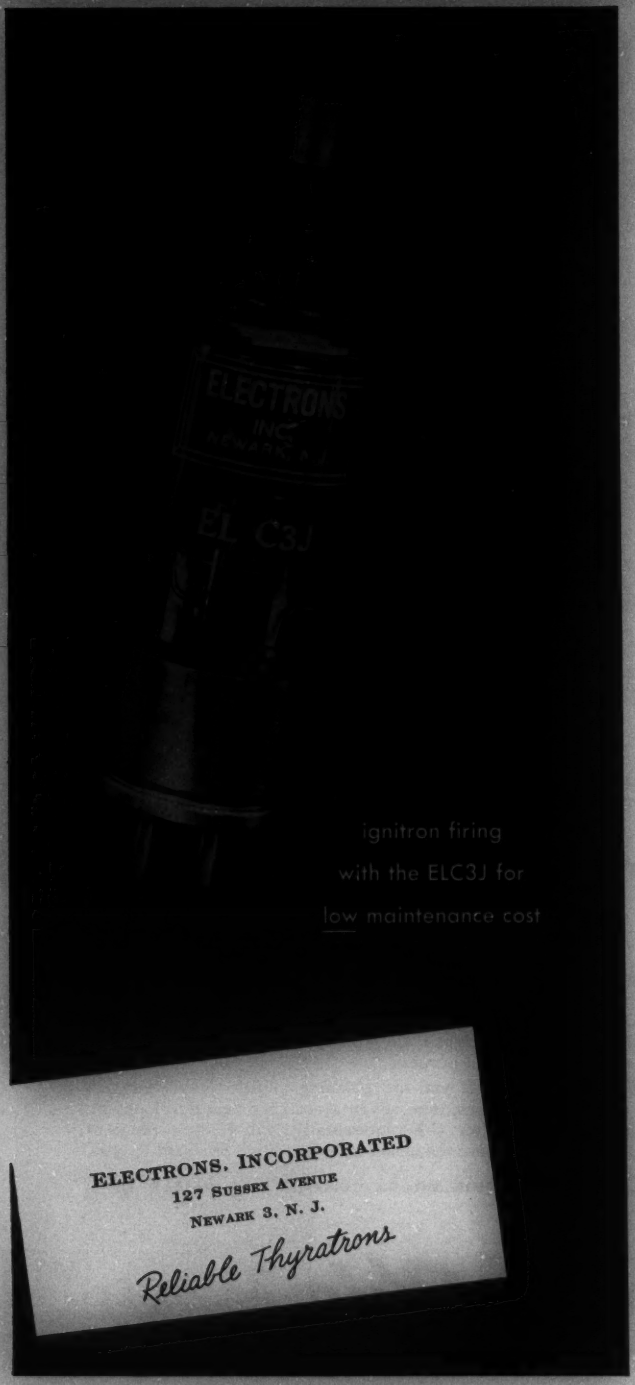


Industrial Notes

(Continued from page 30A)

Acme Electric Corp.
Hawthorne, Calif. . .

A new plant at 12822 Yukon Ave., Hawthorne, Calif., is now the West Coast headquarters of Acme Electric Corp. The progress that the company achieved since establishing its West Coast branch had made the former Los Angeles factory inadequate for its range of activity in the electronic component and transformer field.

Gering Products, Inc.
Kenilworth, N. J. . .

Flame-retardant compounding of thermoplastics on a broadened scale is now being produced by Gering Products, Inc., N. 7th St. & Monroe Ave., Kenilworth, N.J.; they include flame-retardant polyethylene, polypropalene, and polystyrene (general purpose and impact grades), in addition to the various flame-retardant cellulosics and vinyls which the company has marketed for the past 10 years.

Carrier Corp.
Syracuse, N. Y. . .

A contract to build a 5,000 watt thermoelectric generator has been awarded to Carrier Corp. by the U. S. Navy Bureau of Ships. The unit will be 15 to 20 times more powerful than experimental devices developed to date. It is potentially noiseless and vibration-free. Conventional electromagnetic systems require boilers, turbines, and generators or other prime movers such as water power plus a generator. Pointing out that only heat is required to produce electricity with this unit, Dr. J. F. Smith, vice president in charge of the company's central Research and Development Division, noted that these unique generators could be powered by natural heat from the sun or even heat escaping from industrial chimney stacks, which currently is wasted.

Burroughs Corp.
Detroit, Mich. . .

The manufacture of business machines in France is being expanded by Burroughs Corp. with the purchase of a 110,000 square foot factory, located on 25 acres at Villers-Ecalles, 14 miles northwest of Rouen, according to R. W. Macdonald, vice-president, International Division. When in full operation, the plant will have an initial employment of approximately 600 people in the fabrication and assembly of Burroughs Ten Key adding machines. Machines produced at Villers-Ecalles will be distributed throughout France and international markets.

(Continued on page 36A)

Bendix G-15

PUNCHED CARD AND TABULATOR COUPLER

...a new accessory for the Bendix G-15 Digital Computer for low cost, high performance punched card computing

Now, at a cost significantly below that of any similar equipment, Bendix provides a complete computing system with 100 card per minute punched card input and output, and 100 line per minute tabulation.

Heart of the system is the Bendix G-15 general purpose digital computer, which has proven its performance in well over 150 successful installations.

The CA-2 coupler, a newly developed G-15 accessory, enables the computer to operate in conjunction with conventional punched card and tabulating equipment.

A full 80 columns of numeric, alphabetic, or special character information can be accommodated using only the CA-2 as a connecting link between the card equipment and the G-15. Any column of the card can contain any one of the three types of information.

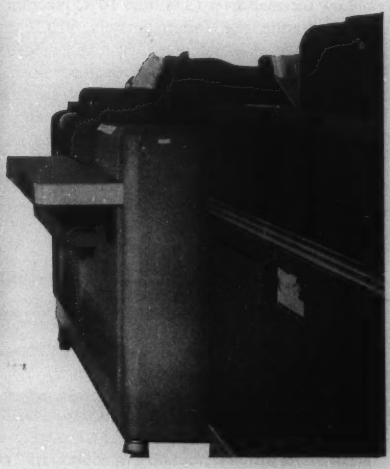
Three input-output units may be connected simultaneously . . . one for input, one for output, and a third for input or output. Data may be read or punched by standard card units, or printed by standard tabulators. All input and output is under complete control of the computer. Computation can proceed during the input or output cycle, thus assuring maximum over-all computing speed.

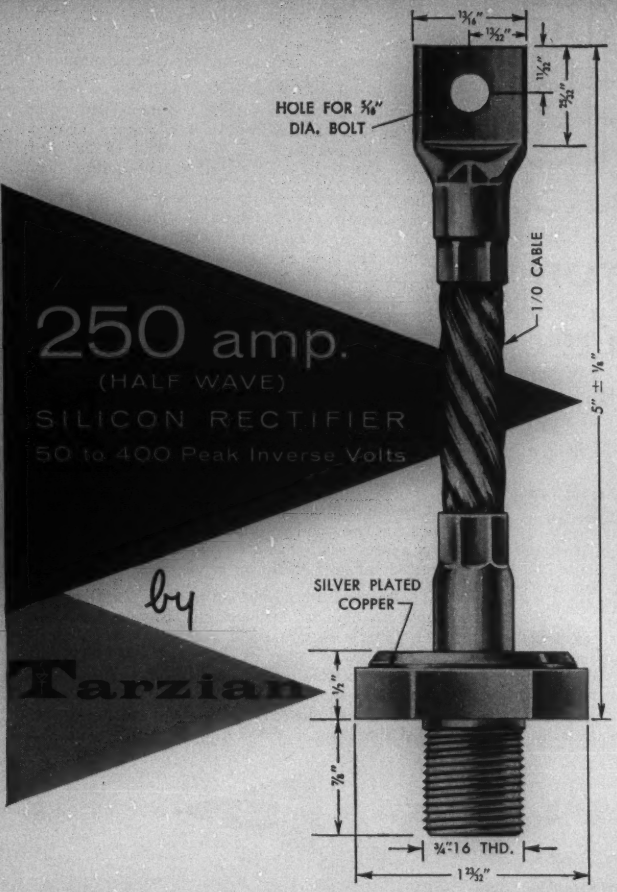
In addition to the CA-2, the computer's typewriter and paper tape equipment, and auxiliary magnetic tape storage units may be used for completely versatile input, output, and storage. Both power and space requirements of the complete punched card computer system are approximately half that of other systems of this type.

A system that includes the G-15 computer, the CA-2 coupler, two summary punches and a tabulator, leases for approximately half the price of a typical medium-priced system with similar capabilities.

Whether you are now using punched card or computing equipment, or if you are delaying such plans due to high costs, you will want to learn more about this inexpensive, efficient equipment. Detailed technical information on the G-15 and the CA-2 will be sent on request. Write to the Bendix Computer Division of Bendix Aviation Corporation, Los Angeles 45, California. Dept. K-11.

Bendix Computer





Low thermal drop (less than 10°C junction to base) and low junction temperature rise (approximately 60°C) are built-in features in the Tarzian Y series rated at 250 amperes d.c. This combination minimizes "thermal-aging" problems and extends life expectancy. Ideally designed for use in welding, electroplating and electrolysis application, this series is also useful in any application that requires 1000 or more d.c. amperes.

CHARACTERISTICS

TYPE NUMBER	5Y3	10Y3	20Y3	30Y3	40Y3
Max. RMS Input Voltage (Volts)	35	70	140	210	280
Max. Inverse Peak Voltage (Volts)	50	100	200	300	400
Max. Peak Current Amps.	1500	1500	1500	1500	1500
Max. RMS Current Amps.	500	500	500	500	500
Max. DC Current Amps.	250	250	250	250	250
Approx. Rectifier Voltage Drop (Volts)	2	2	2	2	2
Max. Ambient Operating Temperature	100°C	100°C	100°C	100°C	100°C
Max. Surge Current (Amps. for 4 MS)	2500	2500	2500	2500	2500
Heat Sink Size (2500 LFM of Air)	4"x5"x1/4" Copper (for all types)				

POSITIVE BASE—TYPE Y3P NEGATIVE BASE—TYPE Y3N

SARKES TARZIAN, INC Rectifier Division

DEPT. E-3, 415 NORTH COLLEGE AVE., BLOOMINGTON, INDIANA

IN CANADA: 700 WESTON RD., TORONTO 9, TEL. ROGER 2-7535 EXPORT: AD AURIEMA, INC., NEW YORK CITY

Industrial Notes

(Continued from page 32A)

IBM
White Plains, N. Y. . .

Nearly tripled speeds for electronic computer magnetic tape units have been announced by International Business Machines Corporation's Data Processing Division, 112 E. Post Rd., White Plains, N.Y. The transistorized model *729 II* tape unit is now capable of reading or writing both at its former density of 200 characters per inch and a new density of 555 characters per inch. This will have the effect of increasing input and output speeds from 15,000 characters per second to 41,667. Either or both speeds may be chosen depending upon the program used. There is no increase in the monthly rental rate. The transistorized *729 IV* tape unit also will be capable of operation of either density. Under program control, it will read or write either at 22,500 or 62,500 characters a second. Coupled with the increased speed announcement is a price reduction for the *729 III's* and *IV's* amounting to 20%.

Eastman Chemical Products, Inc.
New York, N. Y. . .

In a unique picture-screen shield molded of transparent Tenite butyrate plastic supplied by Eastman Chemical Products, Inc., 260 Madison Ave., New York, N.Y., picture tube and screen have been removed from their conventional position in the cabinet and housed as a separate, slim, portable unit. The new shield of butyrate, chosen for its outstanding toughness and impact strength, serves as protective housing over the front of the unit. It is molded in one piece, convex at center and curved around on all sides in a 2-inch rim which joins the rear housing. The transparent butyrate is lightly tinted to prevent glare and lacquered in green toward its outer edges to frame the picture area. The light weight of the butyrate shield, 2½ pounds, increases portability, and is one factor in the ability of the separate screen to stand firmly on its slender neck and small base.

United Sensor & Control Corp.
Glastonbury, Conn. . .

Aerotech Specialties Inc. has had its name changed to United Sensor & Control Corp.; it is to remain at the same address, Box 127, Glastonbury, Conn. A subsidiary of United Electric Controls Co., Watertown, Mass., US&C designs and manufactures thermocouple probes for temperature measurement, pressure probes for flow velocity and direction measurement, mercury slip rings for strain gauge and thermocouple measurements on high-speed shafts, and remote controlled positioning units.

(Continued on page 42A)

What's the difference in electrical cable?

You can install USS Armorlokt in half the time — at half the cost

Take a close look at the main illustration. With Tiger Brand Armorlokt Interlocked Cable, it's a simple job to run power and light lines around a steel beam. We know, from experience on other jobs, that a conduit system would require about twice as much time to install. It would probably have required larger size cable, because of the higher voltage drop . . . *and it would cost about twice as much!*

Greater current-carrying capacity. For a given conductor size, Armorlokt will have a higher current capacity than three single conductor cables pulled into a steel conduit. As an example, 500 MCM 3-conductor varnished cambric cable with galvanized steel interlocking armor will have a current-carrying capacity of 417 amperes with a copper temperature of 85°C. Three single conductors of the same size in a steel conduit will have a current-carrying capacity of 380 amperes. Putting it another way, 350 MCM Armorlokt might serve, where 500 MCM would otherwise be required in conduit . . . a big saving in favor of Armorlokt.

Less material—less space. With Armorlokt, costly pipe fitting, bending and pull boxes are eliminated. Installation time is cut approximately in half. Space savings as high as 55% to 75% over conduit are common.

Greater layout flexibility. When distribution systems are laid out with easily-accessible, readily-traceable Armorlokt Cables, it is a simple matter to change machinery locations. This might well be a deciding factor in industrial plants.

Ease of maintenance. Armorlokt Cable permits the greatest possible ease of maintenance. Cable faults are readily located and serviced. If Armorlokt should become damaged, you simply insert a splice box.

USS Tiger Brand Armorlokt Cable is available in voltage ratings from 110 to 15,000 . . . with galvanized, stainless steel, aluminum or bronze armor . . . with polyvinyl chloride jackets over the armor for especially corrosive applications. For complete facts, write American Steel & Wire, Dept. 982, 614 Superior Avenue, N.W., Cleveland 13, Ohio.

USS, Tiger Brand and Armorlokt are registered trademarks

American Steel & Wire Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors
United States Steel Export Company, Distributors Abroad

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"Complete Semiconductor Power Conversion Systems for any AC to DC application"

S-95 Second Symposium on Polyethylene Wire and Cable Insulation (*October 1958*)

This symposium was held at the AIEE Winter General Meeting in New York, N. Y., January 21-25, 1957, and was sponsored jointly by the Insulated Conductors Committee and the Dielectrics Committee of the AIEE.

The eleven papers in the 51-page publication cover:

- Developments in Polyethylene Insulation
- Thermal Embrittlement of the More Crystalline Polyethylenes
- Polyethylene in Wire and Cable Use
- Irrathene Irradiated Polyethylene
- Impulse Breakdown of Electrically Prestressed Polyethylene
- Use and Performance of Polyethylene Power Cable in Chemical Plants
- Applications of Polyethylene in the Wire and Cable Industry
- Polyethylenes for Higher Voltage Cables
- Use of Polyethylene Conductors on the Niagara Mohawk System
- Four Years of Experience with High-Voltage Polyethylene Power Cables
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Industrial Notes

(Continued from page 36A)

Eaton-Peabody Laboratory Boston, Mass. . .

A unique laboratory for studying the physiology of hearing has been established by the Massachusetts Eye and Ear Infirmary and the Massachusetts Institute of Technology. Doctors, neurophysiologists, and electrical engineers will work together in a program of research, treatment, and education which, it is hoped, will contribute to the understanding of the basic phenomena of hearing and help solve some of the problems of deafness. The new sound-proof and vibration-proof laboratory was built and equipped at a cost of $200,000 and will be operated under grants from the National Institutes of Health. Located at the Infirmary in Boston, Mass., it is known as the Eaton-Peabody Laboratory of Auditory Physiology.

ACF Industries, Inc. Paramus, N. J. . .

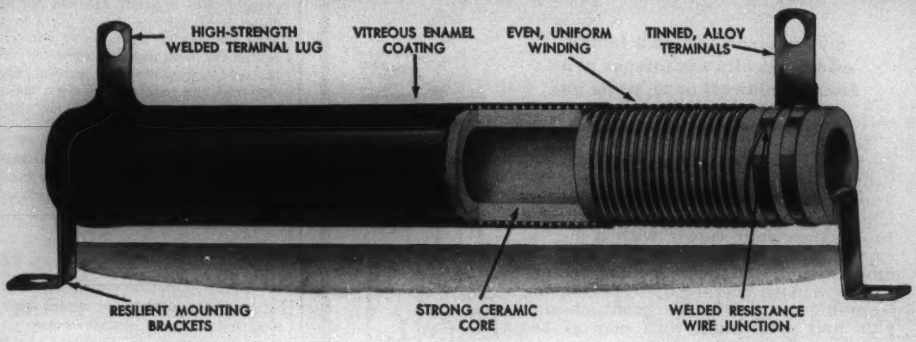
An Air Research and Development Command contract to study methods of detecting infrared radiations from satellite vehicles has been awarded to the Avion Division of ACF Industries, Inc., 11 Park Place, Paramus, N. J. The research contract is part of the program at the Geophysics Research Directorate, Air Force Cambridge Research Center, L. G. Hanscom Field, Bedford, Mass., to explore possibilities of detecting and tracking satellites by infrared techniques. The basic problem of Avion, in developing a device to detect satellite vehicles by infrared, is to make the system so selective that it will not be confused by infrared emissions from the sun or other heat producing or reflecting space bodies.

Lenkurt Electric Co. San Carlos, Calif. . .

Telefonos de Mexico (Telmex) has turned the rugged terrain of southern Mexico into an ally instead of an obstacle in opening a new radiotelephone link between Mexico City and Acapulco. The largest Mexican microwave project to date, the new system was planned by Telmex and Lenkurt de Mexico engineers aided by the "Engineer, Furnish, and Install" group from Lenkurt's United States firm at 1105 County Rd., San Carlos, Calif. Mexico's capital city is surrounded by mountains including the snow-capped crests of Popocatepetl and Ixtacihuatl to the south and east. Many lesser ranges and volcanic peaks lie between the central highlands and the west coast resort city. Taking full advantage of these terrain features, Telmex has placed in service a Type 72C 900-mc radio relay system spanning the 227-mile distance in four line-of-sight hops, with a single hop of 132 miles dramatically illustrating how to make the most of mountainous topography.

(Continued on page 44A)

Quality Features of OHMITE® VITREOUS ENAMELED RESISTORS



Balanced Thermal Expansion prevents crazing and moisture entrance

In Ohmite resistors, spot welding replaces soldering, brazing, and mechanical fastening. Spot welding produces strong connections that are not affected by vibration or high temperatures. Ohmite welded construction also produces an almost flush connection between the resistance wire and terminal. This prevents thin spots or bulges in the vitreous enamel coating which might cause future trouble and failure. Many different types of terminals are available besides the lug illustrated.

Ohmite can supply all of your resistor needs

some of the many types available

- Axial Lead
- Brown Devil® Wire Lead
- Fixed, Lug Type
- Dividohm® Adjustable
- Thin Type
- Noninductive
- Powr-Rib®, High Current, Round or Ribbon Wire, Open Wound
- Corrib®, High Current, Corrugated, Edgewound Ribbon
- Resistors with Heat Conducting Studs
- Ferrule Mounting Resistors
- Live Bracket Mounting Resistors
- Edison Screw Base Mounting Resistors
- Ritechm® Wire-Wound Precision Resistors, Encapsulated; Vitreous Enameled; Molded Jacket; Hermetically Glass Sealed
- Ritechm® Metal Film Resistors
- Resistors to meet MIL Specifications
- High-Shock Resistors

Write on company letterhead for Catalog 58

The almost endless variety of Ohmite resistors in many sizes and types—in a wide range of wattages and resistances—makes it possible to meet each individual need. Many of these can be supplied from the world's largest factory stock. Whatever your resistor requirements may be, chances are you will find exactly the type you need in industry's most complete line of high-quality resistors.

Be Right with OHMITE® Quality Components

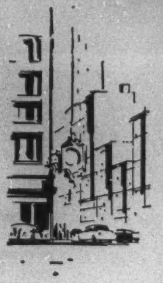
Ohmite Manufacturing Company
3614 Howard Street
Skokie, Illinois

RHEOSTATS RESISTORS RELAYS
TANTALUM CAPACITORS TAP SWITCHES
VARIABLE TRANSFORMERS DIODES R.F. CHOKES

ENGINEERS...PHYSICISTS

NEW opportunities at Motorola in Chicago

give yourself and your family all the big city advantages at a relaxed midwest pace, while you ADVANCE YOUR CAREER



Outstanding career opportunities are waiting at the many Motorola research and development laboratories in the Chicago area. This is your opportunity to advance your career with a swiftly expanding company, working in the most modern and well instrumented laboratories . . . with liberal employee benefits, including an attractive profit sharing plan and association with men of the highest technical competence.

You'll like living in one of the beautiful suburbs of the playground of the midwest, where there are endless social, cultural, and educational activities to choose from the year-round. Exciting life or quiet life—Chicago offers either.

MILITARY
POSITIONS OPEN

- Radar transmitters and receivers
- Radar circuit design
- Antenna design
- Electronic countermeasure systems
- Military communications equipment design
- Pulse circuit design
- IF strip design
- Device using kylstron, traveling wave tube and backward wave oscillator
- Display and storage devices

CIVILIAN
POSITIONS OPEN

2-WAY RADIO COMMUNICATIONS
• VHF & UHF Receiver • Transmitter design & development • Power supply • Systems Engineering • Selective Signaling • Transistor Applications • Crystal Engineering • Sales Engineers

PORTABLE COMMUNICATIONS
• Design of VHF & UHF FM Communications in portable or subminiature development.

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ALSO . . . there are excellent opportunities in
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MOTOROLA

Industrial Notes

(Continued from page 42A)

Electric Storage Battery Co. Philadelphia, Pa. . .

A completely automatic charger for electric industrial truck batteries, which rides around right on the battery itself, has been introduced by Exide Industrial Division of The Electric Storage Battery Co., 42 South 15th St., Philadelphia 2, Pa. The silicon-rectifier device, with a transistorized control unit, need only be plugged into a handy 115-volt, a-c wall outlet to charge the battery right in the truck. No further attention or additional equipment is needed. Automatically and precisely maintaining the proper charge rate from the beginning of the cycle, the new charger, designated Exide Power Mount, provides a fully automatic taper-rate charging system, saves space, labor, and downtime, keeps batteries performing at peak capability, assures longer battery life, and minimizes battery maintenance.

Lockheed Aircraft Service New York, N. Y. . .

A mobile field X-ray service for airlines and executive aircraft operators has been inaugurated by Lockheed Aircraft Service, New York International Airport. Smaller fleet operators and single aircraft owners can not incorporate nondestructive testing and inspection methods into their own maintenance and overhaul programs using the new service. The mobile unit is equipped with the latest portable X-ray apparatus and manned by a team of engineers and aircraft inspection technicians. They are prepared to plan and implement X-ray programs tailored to meet individual requirements of small fleet operators and executive and private aircraft owners at any operations or maintenance base. X-ray avoids time-consuming disassembly and provides more reliable inspection of structural members, control surfaces, overlapped or multilayer sections, as well as a variety of critical welds; it has also been utilized for the detection of foreign materials in sealed or inaccessible areas.

P. R. Mallory & Co. Inc. Du Quoin, Ill. . .

A new P. R. Mallory & Co. Inc. division, to be known as the Elkon Division, which headquarters at Du Quoin, Ill., consists of an electromagnetic department and a semiconductor department. The electromagnetic department is the successor to the former P. R. Mallory Vibrator Division. In addition to vibrators, the electromagnetic department will manufacture choppers, relays, and other electromagnetic devices. The semiconductor department has facilities at Indianapolis and Du Quoin for the manufacture of silicon rectifiers. Other semiconductor products will be added in the near future.

Senior Chemists, Physicists, Metallurgists and Engineers for

FUEL ELEMENT DEVELOPMENT

Fuel Materials. Senior Physical Metallurgists and Chemists for research and development of reactor fuels. Research in gas-metal systems, emphasis on structural, phase equilibria, and material properties.

Alloy development of fuel and cladding materials for operation in power reactors up to temperatures of 1200°F. and higher.

Study radiation effects, overall evaluation of uranium and alloys and ceramics.

Fuel Fabrication. Senior Metallurgical, Mechanical and Chemical Engineers for fabrication development of materials and elements. Includes both rod-type and plate-type elements and complex assemblies. Development of non-destructive tests for these elements.

Irradiation Experiments and Hot Lab Evaluation. Senior Physicists, Chemists and Engineers to develop and conduct irradiation experiments to establish the behavior of fuel materials and prototype fuel elements under conditions of temperature and radiation anticipated in full scale power reactors. Also Senior personnel to develop techniques and equipment for the post-irradiation testing and evaluation of these experiments.

Write today for more details about exciting career opportunities: Mr. E. F. Newton, Personnel Office, Atomics International, 21600 Vanowen Street, Canoga Park, California.

ATOMICS INTERNATIONAL
A DIVISION OF NORTH AMERICAN AVIATION, INC.

Trade Literature...

Movie on EHD Faultmaster Cutout . . .

A 10-minute 16-mm sound and color film on their new *EHD* Faultmaster cut-out has been prepared by Hubbard personnel in both normal and high-speed photography. The movie graphically demonstrates the positive action of the Hubbard single-vent, small-bore design through actual operating tests in an entire range of currents. **Hubbard and Co., Advertising Department, 200 S. Michigan Ave., Chicago 4, Ill.**

Miniature Pulse Transformer Bulletin . . .

A technical bulletin describing the *P* Series miniature encapsulated pulse transformers, designed especially for printed circuit and automatic assembly applications, and available in a number of case styles with a range of pulse widths from 0.05 to 10 microseconds for either vacuum tube or transistor applications, has been published by **Technitrol Engineering Co., 1952 E. Allegheny Ave., Philadelphia 34, Pa.**

Dual Channel System Brochure . . .

Weinschel Engineering's Application Notes No. 4, describe a dual channel system for measurement of insertion loss up to 20 db with an accuracy of 0.02 db per 10 db at any frequencies for which power sources and bolometers are available. The brochure has been revised to include equipment put on the market since the original edition. **Weinschel Engineering, 10503 Metropolitan Ave., Kensington, Md.**

Booklet on Plasma Arc Coating . . .

"Plasmarc" plating, describes the new plasma arc service for metals in the high-temperature range. Copies may be obtained by writing to New Products Department, **Linde Company, Division of Union Carbide Corporation, 30 E. 42nd St., New York 17, N. Y.**

Numeral Frequency Chart . . .

This chart shows the frequency of numbers one through zero, when individual numbers are used for consecutive marking from one through 1999, and it also indicates the correct quantity of self-sticking numbers to be used in consecutive marking. Write **W. H. Brady Co., 727 W. Glendale Ave., Milwaukee 9, Wis.**

Bulletin on Fluid Filtration System . . .

Bulletin No. 1381, describes a 2-5 micron fluid filtration cart, Model *9545*, which is designed for use in precision hydromechanical circuits on missiles, aircraft, and other hydraulically operated devices. **George L. Nankervis Co., 15400 Fullerton, Detroit 27, Mich.**

Catalog on Powered Industrial Trucks . . .

The 12-page literature classifies truck types under: fork trucks, heavy-duty fork and ram trucks, low lift platform trucks, high lift platform trucks, die handling trucks, and mobile cranes. **The Elwell-Parker Electric Co., 4205 St. Clair Ave., Cleveland 3, Ohio.**

Driving Simulator Explained . . .

An article by Charles Hutchinson, on the feasible development of a driving simulator to study driver behavior in accident situations, appears in Vol. VI, No. 4, Winter 1959, "Research Trends," published by Cornell Aeronautical Laboratory, Inc. The use of such a device will enable researchers to investigate scientifically the factors which affect human driver performance in traffic situations. The simulator would be much like an airplane mockup that is used in pilot training. **Cornell Aeronautical Laboratory, Inc., Buffalo 21, N. Y.**

Digital-Instruments Bulletin . . .

A 4-page illustrated bulletin describing the complete KIN TEL line including voltmeters, ratiometers, ohmmeters, preamplifiers, input scanners, and a variety of accessories for driving card punches, tape punches, and printers of digital instruments is now available. For copies of Catalog No. *19-36* write **KIN TEL Division, Cohu Electronics, Inc., Box 623, San Diego 12, Calif.**

"How To Select a Strain Gage" . . .

This 24-page article comparing the characteristics of resistance strain gages made by eight United States manufacturers specifies selection criteria for various strain gage properties under different operating conditions. Reprinted from Vol. II, No. 1, Strain Gage Readings, the periodical is devoted exclusively to strain gages, strain gage transducers, and associated instrumentation. **Stein Engineering Services, 5602 E. Monte Rosa, Phoenix, Ariz.**

(Continued on page 71A)

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(Continued from page 55A)

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(Continued on page 64A)

Trade Literature

(Continued from page 57A)

Pump Recirculation Control Systems . . .

A pump recirculation control system to maintain safe, adequate pump flow at all times is described in Bulletin *560*. Both pneumatic and electric systems for increasing pump flow by recirculation are shown. **Bailey Meter Co., 1050 Ivanhoe, Rd., Cleveland 10, Ohio.**

Spectrophotometer Bulletin . . .

This 12-page brochure discusses features, performance, construction, operation, and accessories of the Model *14* recording spectrophotometer which is used for rapid recording of spectra where a high degree of precision and accuracy is required. Bulletin No. 114 is available from **Applied Physics Corp., 2724 S. Peck Rd., Monrovia, Calif.**

Stranding Chart . . .

An easy-to-use wire stranding chart, *ZK-4*, making it possible, through the use of a one-page reference, to determine available stranding combinations rapidly for various sizes of conductor wire, is available from **Alpha Wire Corp., 200 Varick St., New York 14, N. Y.**

Radioactivity at Work . . .

The current issue of Radioactivity at Work No. 15, reviews some radioisotope techniques under investigation for the Atomic Energy Commission, which are expected to contribute further toward our Nation's technical program. **Nuclear Science and Engineering Corp., Section 5-P, P. O. Box 10901, Pittsburgh 36, Pa.**

Hydraulic, Pneumatic and Vacuum Catalogue . . .

Contained in this catalogue are flow charts, information on Joint Industry Council piping, and complete data on Lenz *O* ring-seal tube fittings, tube benders, and other hydraulic components. **Lenz Co., Box 1044, Dayton 1, Ohio.**

Electronic Components Catalog . . .

This 256-page catalog contains detailed information and specifications on a wide variety of electronic components and equipment for service, industrial, and sound applications. It is especially noteworthy for its comprehensive listing of amateur radio products. **Electronic Publishing Co., Inc., 180 N. Wacker Dr. Chicago 6, Ill.**

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